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1. Throughout this report, for Physico-Chemical Institute read Institute of Physical Chemistry, for Geo-Chemical Institute read Institute of Geochemistry and Analytical Chemistry, i/n Vernadskogo.
2. Throughout this report:  

For:	Read:
Chevchenko	Shevchenko
Verkhniy Neyvinskiy	Verkh-Neyvinskiy
Eshery	Esheri
Burdiashvili	Burdiyashvili
Vollmer	Volmer
3. Karzhavin, Meyzerov, Kirvalidze, and Kosyrev, referred to throughout this report, have also been received as Karshavin, Mezerov, Kirovalidze, and Kosirev, respectively.
4. The IRPA, referred to throughout this report, is the Institute of Radio Reception and Acoustics, also reported as the Scientific Research Institute of Radio Reception and Acoustics.
5. On page 14, Ruktsov has also been reported as Rubtsov and Ruptsov.

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(NOTE: Washington distribution indicated by "X"; Field distribution by "#".)

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6. In paragraph 39, [Boris Ilyich] Vannikov should read Boris Lvovich Vannikov.
7. In paragraph 58, [B. A.] Malyshev is V. A. Malyshev, now Deputy Chairman of the Council of Ministers of the USSR and Chairman of the State Committee for New Technology of the USSR Council of Ministers.
8. In paragraph 80, [Oleg] Poroshin is possibly Aleksandr Poroshin.
9. In paragraph 119, for Vinogradov Institute for Geo-Chemistry read Institute of Geochemistry and Analytical Chemistry i/n Vernadskogo headed by Vinogradov.
10. In paragraph 121, Smorodinskiy (fnu) is possibly Professor Ya. A. Smorodinskiy, who has been associated with the Institute of Physical Problems.
11. In paragraph 135, the Krasnyy Proletariy factory is more properly identified as the Moscow Krasnyy Proletariy Machine-Tool Building Plant i/n A. I. Yefremova, 15 Malaya Kaluzhskaya ulitsa, Leninskiy Rayon.
12. In paragraph 252, for Zimwaldite read Zinnwaldite.
13. In paragraph 255, for Tjujamumit (sic) read tyuyamunite, and for Ferghana read Fergana.

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REPORT

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3. In this report a detailed description will be given of the standard mass spectrometer [redacted] and of the automatic gas analyzer. In addition to design specifications, tables and graphs depicting experimental results obtained through the years are also furnished. Various modifications together with explanations as to inherent advantages of the variations are also given.

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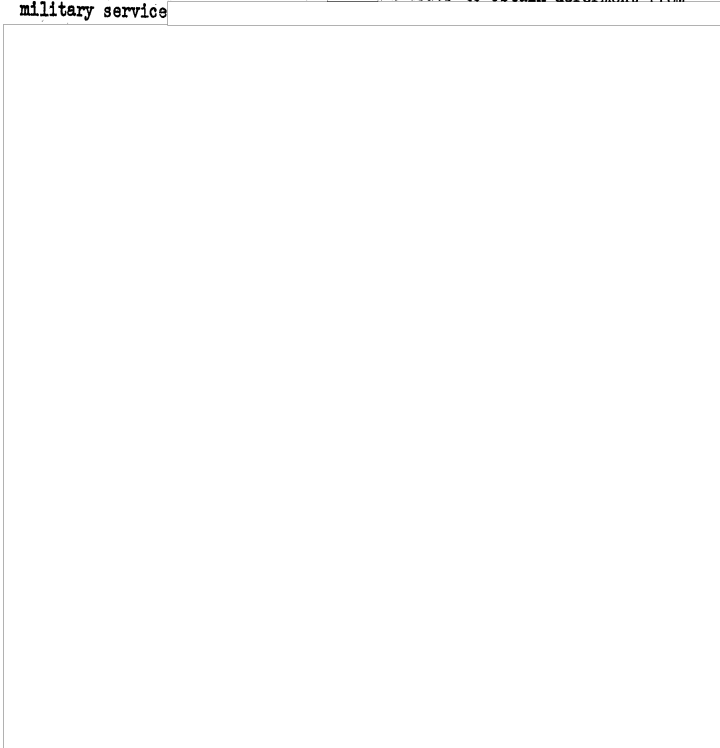
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8. No section of the Siemens plant was enrolled in the German atomic effort during the war. Neither Hertz nor [redacted] any official contact with this enterprise, which was first under Johannes Stark and later under the administrator Albert Speer and the scientist Walther Gerlach, except for the closing phases of the war [redacted] in order to obtain deferment from military service [redacted]

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9. Upon the end of hostilities, a Soviet dismantling group took charge of Siemens A.G., and began the systematic dismantling and crating of Siemens equipment for shipment to the USSR. Of the Siemens dismantling group Soviet officer Abramovich (fmu), who headed the section responsible for the research laboratory. This laboratory equipment was to be used to equip the Electro-Technical Institute in Kharkov, and crates allegedly received the imprint: KhETI. Later, when the Agudzeri installation faced a shortage of facilities, the Germans requested some of this Siemens equipment from Kharkov, and after much effort some of the inferior equipment was transferred from Kharkov to Agudzeri.

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11. Col. Nemënov was a member of a group of Soviets under the leadership of Lt. Gen. Avraamiy Pavlovich Zavenyagin, which had its office in Berlin-Gruensau and which was charged with enrolling Germans who had participated in the German atomic work and with enrolling other Germans who might contribute to the Soviet atomic effort. This Soviet organization was absolutely separate from the Soviet dismantling group at Siemens. Zavenyagin was evidently especially interested in the Kaiser Wilhelm Institute in Berlin-Dahlem, and Hertz, later in the USSR, was asked by Zavenyagin whether it would be desirable to enroll among others Werner Heisenberg, Karl Friedrich Bonhoeffer, Helmuth Kulenkampff and Rudolf Seeliger.

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12. At about the time Prof. Hertz had been contacted by MVD Col. Isaak Konstantinovich Kikoin, the only other member of Zavenyagin's Berlin-Gruensau staff Hertz had been invited to perform independent research in the USSR, and a number of Hertz's acquaintances had asked for permission to accompany him to the USSR. Upon Hertz's acquiescence, the Soviets rubber-stamped Hertz's selections.

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3. In respect to all members of the Hertz Group the initiative to go to the USSR came from the respective German with no pressure coming from Hertz.

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13. The Hertz group which was assembled during June 1945 for transfer to the USSR numbered about one dozen specialists, including: Werner Hartmann, Justus Muehlenpfordt, Helmut Bumm,<sup>4</sup> Karlfranz Zuehlke,<sup>5</sup> Gustav Richter, Max Saegel, Eduard Kraemer, Reinhold Reichmann, Alfons Staudenmaier,<sup>6</sup> and Ernst Hottmann. The last two were recruited for the purpose of assisting in the reconstruction of the Siemens cyclotron. Max Vollmer, too, initially was counted among the Hertz group, but shortly after their arrival in the USSR some tension arose between the two, and Vollmer left Hertz and was transferred during spring 1946 to Laboratory 9. Richter transferred together with Vollmer, as his health did not permit a sojourn in the region in which Hertz's institute was established.

14. While the Hertz group was being assembled in Berlin, the Zavenyagin group was enrolling key Germans and their staffs. It appears that on the whole the Soviet atomic exploitation group captured only a small fraction of the German wartime nuclear scientists. Although many fled westward in order to escape the Soviets, there were also those who hid from the Americans and awaited the withdrawal of US advance elements from East Germany in order to place themselves at the disposal of the Soviets. Among these were Heinz Pose and Georg Robert Doenal.

15. Hertz and probably the other German group leaders were not advised by the Soviets that their principal activity in the USSR would be in support of the Soviet atomic-weapons program, and it was to some extent a coincidence that the assistants chosen by the various group leaders and rubber-stamped by the Soviets were able to do work in nuclear research, which to many was a completely new field. Zavenyagin, having missed the bulk of the German atomic energy scientists, took everyone that might help the Soviet effort without especially scrutinizing the human spoils of war.

#### HIGHLIGHTS FOR THE YEAR 1945

##### Ozery

16. The Hertz group left Berlin by plane on 13 June 1945, and stayed until August 1945 at a rest home in the village of Ozery where their movement was not restricted. The rest home had once belonged to Genrik Grigoryevich Yagoda, the late chief of the NKVD, and during the war housed the captured

among the first things the Soviets discussed with Hertz was his recent work in isotope separation, since they did not show the slightest interest in the activity of the Siemens Research Laboratory, when they discovered that the laboratory had not worked on atomic energy during the war, and since they were interested in mass-spectrometric work.

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German Field Marshal Friedrich von Paulus. In an effort to relieve the boredom, the Germans held colloquia at which each spoke about his past scientific experiences. Also, since most of the Germans had heard of the Gerlach-Speer enterprise, there was much speculation as to how far the Americans might have come with this project. Certain that the Soviets had as yet not made any progress whatever in this field, [redacted] no speculation about Soviet progress.

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17. [redacted] the Germans received in Ozeri courtesy calls from Gen. Zavenyagin and Prof. Kikoin. Zavenyagin stated that arrangements would be made for a suitable institute, and a few days later Lt. Gen. Mykhnev (fnu), personal adjutant to Minister Lavrentiy Pavlovich Beriia for atomic-energy problems, arrived. He discussed with Hertz the special requirements, and then promised that he would seek suitable quarters in the Crimean region. He also gave permission to the German specialists to correspond with their homes, and said that for this purpose a special courier plane would be available. This was the reason for the early misleading newspaper reports that cited the Crimea as the site of the Germans' institute.

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18. Two weeks later, Mykhnev returned once more with photographs of two sanatoria in Agudzeri and Sinop, of which Hertz chose the first leaving Sinop to Manfred von Ardenne and his group of German specialists. These photographs of Mykhnev were shortly after to appear in the Western press, for early in 1946 Frau Vollmer, Frau Gerda Langsdorff (von Ardenne's secretary), Staudenmaier, and Kraemer flew from Agudzeri to Berlin. Upon arrival, Kraemer fled to West Berlin where he entered a hospital and informed the Soviets that he would not return. Upon receipt of this news, Staudenmaier, Frau Langsdorff, and Frau Vollmer were quickly rounded up in Berlin-Gruenau and immediately were flown back to the Soviet Union.

Meeting with Beriia, August 1945

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19. Early in August 1945, the Hertz group left Ozeri for Agudzeri. Hertz, Vollmer [redacted] however, were held back in Ozeri with instructions to prepare for a conference with Beriia.
20. On the evening of either 23 or 24 August 1945, a Soviet officer arrived in Ozeri to bring the three Germans from Ozeri to Beriia, but before leaving the grounds [redacted] the officer upon reviewing the roster found that it contained only Hertz, Vollmer, von Ardenne,

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9. Heinz Barwich, too, was to return to Germany, but at the last minute was held back in Moscow. [redacted] Frau Langsdorff was to return in order to enroll additional assistants for von Ardenne; Staudenmaier and Kraemer were to collect design drawings for the Siemens' cyclotron which were lost in the shuttle from Berlin to the USSR. Frau Vollmer's reason for returning to Berlin was of a personal nature.

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Nikolaus Riehl<sup>10</sup> and possibly Peter Adolf Thiessen. [redacted] 25X1  
 [redacted] originally scheduled to meet with Beriya is another indication 25X1  
 of the high priority which mass-spectrometer development held at this  
 time. [redacted] 25X1

21. [redacted] uranium isotope separation was  
 not mentioned by the Soviets until sometime after the arrival of the  
 Germans in Agudzeri. [redacted] during 25X1  
 this meeting Beriya discussed the possibility of their working on various  
 uranium isotope-separation methods with bomb production as a goal. These  
 discussions, however, were of a general nature and did not constitute  
 official assignments. Only in one respect was Beriya precise, namely,  
 that Riehl was to prepare the processing of pure uranium metal.

22. [redacted] 25X1  
 [redacted] the late president of the Academy of Sciences was present as  
 were the Academy members: Igor Vasilyevich Kurchatov, Abram Isaakovich/  
 Alikhanov, Abram Fedorovich Ioffe and Aleksandr Naumovich Frumkin.  
 The latter had been befriended by Vollmer while he was working in Germany  
 prior to 1933. In addition, there were many uniformed officials of whom  
 source could identify only the Generals Zavenyagin and Mykhnev. Kikoin  
 acted as an interpreter at this meeting.

23. It was at this Beriya conference that the problem of the utilization of  
 German PW labor was apparently discussed for the first time, and on von  
 Ardenne's initiative. To the chagrin of Hertz and particularly Vollmer,  
 von Ardenne suggested that in order to accomplish the Soviet-sponsored  
 tasks more speedily it would be desirable to search for German skilled  
 labor in Soviet PW camps. This Beriya promised to do, and by the beginning  
 of 1946 PWs began to arrive at all German installations, with von Ardenne  
 receiving the largest detachment. Vollmer, especially, was aghast at  
 what he thought was von Ardenne's arrogance in influencing the lives of  
 hundreds of Germans for the sake of his position with the Soviets. 25X1

24. [redacted] the Beriya meeting came approximately  
 ten days after the explosion of the Hiroshima bomb, but [redacted]  
 there is no evidence to indicate that there was a causal relation between 25X1  
 Hiroshima and the Beriya conference with leading German atomic specialists  
 in the USSR.

#### Issuance of Assignment

25. After the Hertz group was transferred to Agudzeri, they were visited a  
 number of times by Gen. Zavenyagin and Kikoin. Before the end of 1945,  
 when the institute was beginning to take shape, the assignments were

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distributed. The principal projects were the separation of uranium isotopes by countercurrent diffusion to be headed by Prof. Hertz and the development and construction of a mass spectrometer by source. Most of the other sections in Agudzeri constituted only a supporting structure for these two projects. The requirements for the mass spectrometer were briefly as follows: A mass spectrometer was to be built which would permit the measurement of changes in the natural isotope concentration of uranium (as compared to a standard sample) with an accuracy of at least one percent. It was considered desirable, but not absolutely necessary, to be able to achieve absolute measurements of uranium with an accuracy of one percent. Uranium in the form of  $UF_6$  was to be in the ion source, and only in most exceptional cases were other uranium compounds to be used. No other requirements were specified at that time.<sup>11</sup>

26. The Agudzeri assignments were given by Gen. Zavenyagin who headed the MVD Ninth Directorate which [redacted] was in charge of all the work performed at Agudzeri and Sinop Institutes and at other installations where Germans were employed. To supervise the work performed at these installations, Zavenyagin had a staff of administrators and specialists. Responsible for personnel questions in Zavenyagin's office were the following Soviet officers of the MVD /Maks Leontovich/ Kosyrev, Ruktsov (fnu), and Mikhail Mikhailovich Kuznetsov, the latter being the personnel chief.
27. The technical supervision was performed by Referenten (reviewers). A Referent was responsible for keeping abreast with the progress made by the German specialists in a particular scientific project, supplying the Germans in that field with all information consonant with security regulations, and supplying needed materiel and requirements. [redacted] some of the Referenten and their field of responsibility. This is valid to approximately 1951:

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Aleksandr Il'ich Leypunskiy

Chief of the Referenten of the Ninth Directorate from 1945 to around 1947/1948, when he became Kalashnikov's successor as Referent for measuring instruments.

/Vasilii Semenovich/  
Yemelyanov

Successor to Leypunskiy as chief of Referenten until approximately 1950.

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11. The requirements were [redacted] to some extent an outgrowth of discussions [redacted] held at various times during August or September 1945 with Zavenyagin, Kikoin, Hertz, /Georgiy N./ Flerov, Bonch-Bruyevich (fnu), and /Sergey Grigoryevich/ Kalashnikov.

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[Sergey Grigoryevich]  
Kalashnikov

Referent for measuring instruments, including mass spectrometer and alpha counter. This Referent was, therefore, the recipient of reports on mass spectroscopy and his liaison to Gen. Zavenyagin. 25X1

Irina Aleksandrovna  
Inozemtseva

Referent for chemical development (corrosion). Around 1947, she was transferred to Agudzeri, where for a short while she headed the Chemical Department and then continued to work therein in a subordinate position.

Barshevskiy (fnu)

The field of responsibility of this Referent was not known 25X1

28. [redacted] there were many more Referenten in the Ninth Directorate, but [redacted] unable to identify any more and specifically was unable to identify the Referent for isotope separation. Around 1950, the Referenten system was completely reorganized, and the Agudzeri and Sinop installations had henceforth contact with only two Soviet Referenten: Semenov (fnu) and Novikov (fnu), of whom the former was a physicist specializing on transistors. 25X1

#### HIGHLIGHTS FOR THE YEAR 1946

##### Mass-Spectrometer Development

29. [redacted] 25X1
- the Soviets could give [redacted] no technical advice, because "for us nothing exists." Suddenly in fall 1946, the liaison chief of Agudzeri, Aleksandr Ivanovich Kochlavashvili, said, "Here is a letter [redacted] from Moscow; Bonch-Bruyevich said this would be important [redacted] It must be treated as secret." This document contained a Russian translation of a report by Nier describing a mass spectrometer with two receivers for measurement of line. Bonch-Bruyevich [redacted] apologized for the obvious mistakes, but indicated [redacted] no trouble in recognizing them. The circuit diagrams were very crudely drawn, as though done hurriedly by someone who did not understand what he was copying, with many wrong connections and wires ending in air. This translation had A. O. Nier listed as the author of the report; but no place name, date, or number was given to further identify its origin. The substance of the paper was published later by Nier, Ney, and Inghram in 1947 in the Review of Scientific Instruments. The published article was somewhat longer and more complete. [redacted] the resistance values and the other components indicated in the circuit diagrams in the published article were the same as in the report [redacted] received earlier. 25X1
30. [redacted] continued during 1946 to work on a measuring instrument, which referred to as a mass spectroscopy because the ion peaks were displayed on an oscillograph screen. Parallel with the work on this instrument, [redacted] conducted preliminary experiments on a Nier-type ion source which was designed to be used in a more conventional instrument. 25X1

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Supply Conferences at Ninth Directorate, March 1946<sup>12</sup>

31. Except for the December meeting of the Scientific-Technical Council, [redacted] only contact with the Soviets from outside Agudzeri which pertained to mass spectroscopy occurred during March 1946. Throughout the year 1945, [redacted] the deputy director of Agudzeri had been pre-occupied with establishing the various laboratories and obtaining the needed equipment and supplies. These problems carried far into 1946. After repeated efforts to obtain materiel failed, Gen. Zavenyagin approved a visit by Hertz [redacted] to the Ninth Directorate. During spring 1946, [redacted] travelled to Moscow, fortified with lists of the required materials. Meetings in this connection occurred on the upper floors of the headquarters building of the Ninth Directorate located on Sadovaya ulitsa, one block west of Mayakovskaya ploshchad. While Hertz conferred with Gen. Zavenyagin, and among other things laid the ground work for the visit to Laboratory 2 of Kikoin [redacted] met with a number of unidentified Soviet officers in MVD uniform. Each of these appeared to be a technician responsible for a particular line of equipment. Of particular need were vacuum pumps for Hertz's experiments, vacuum gauges, and diverse electronic equipment such as amplifiers and auxiliary equipment, as well as a multitude of chemicals. 25X1
32. The significance of this meeting is that it highlights the problem that was to plague source on his mass-spectrometer project for the first three years in the USSR, that is, lack of high-quality equipment. It became evident that materials required for the mass spectrometer were especially scarce. Even analytical-grade chemicals were not available, and it became necessary for Agudzeri scientists to prepare their own. [redacted] because of the chaos wrought by the war it was difficult to supply the institute, that part of the required materials would have to be supplied by other institutes in the USSR, and that in some cases it would be necessary to import needed goods from foreign countries. In general terms, reference was also made to factories in the USSR that might be in a position to supply required materials, but care was taken by the Soviets not to identify by name or code designation any Soviet installation. As a matter of fact, throughout [redacted] ten-year stay in the USSR, the Soviets exhibited particular security consciousness in this connection. 25X1
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12. [redacted] a conference held with 10 Soviet scientists [redacted] proposed mass-spectrometer development program. Among these were Alikhanov, Kurchatov, and Kikoin. This conference allegedly was held in March 1946 [redacted] 25X1

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33. Approximately six months after the supply conference, the first batches of supplies, but no more than 20 percent of the order, arrived in Agudzeri. Much of it, especially the electronic equipment, stemmed from wartime US lend-lease materiel. American rotating pumps also arrived, but no vacuum diffusion pumps needed by Hertz for his countercurrent-diffusion experiments were received. These pumps, therefore, had to be constructed by the Germans themselves in Agudzeri during 1946. In connection with supplies, Gasperin (fnu), who seems to have been a leading official in the Ministry of Chemical Industry, came to Agudzeri during 1946.

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Meeting of the Scientific-Technical Council, December 1946

34. Towards the end of 1946, the leading members of Institute G in Agudzeri and Institute A in Sinop were summoned to Moscow to appear before a committee of leading Soviet atomic scientists. Similar meetings were held each year thereafter until 1949 and possibly later. Because they occurred shortly before Christmas they have been referred to as "Christmas meetings". [redacted] not certain about the exact name of the Soviet committee, but [redacted] referred to [redacted] as the Scientific-Technical Council (Wissenschaftlicher Technischer Rat).<sup>13</sup>

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35. [redacted] this council reviewed the progress in the over-all atomic-research program in the USSR and reported to a higher governmental body, possibly the Council of Ministers. Ilya Filippovich Kvartskhava told [redacted] that the Council was not the highest body, as its decisions were reviewed by a still higher office. This, according to Kvartskhava, explained the delay in receiving the final and officially-approved annual plan from Moscow. [redacted] these reviewing bodies were standard in the USSR and that all or most Soviet ministries held annual sessions to study past work and to plot the future course.

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36. The first meeting of the Scientific-Technical Council [redacted] in 1946

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37. Approximately one or two weeks prior to the conference, Hertz and Barwich [redacted] were told by the Soviet administrator Zhdanov (fnu) in Agudzeri to prepare the material necessary for an annual report for transmittal by courier to Moscow. Since each section or department in Agudzeri was in the habit of submitting to the director quarterly reports, the required resume was quickly prepared. This, together with graphic material, was handed to Zhdanov, and upon the Germans' arrival in Moscow it was returned to them. Similar arrangements were made in Sinop, which was represented at the Moscow meeting by Manfred von Ardenne, Max Steenbeck, and Peter Adolf Thiessen. While waiting for the meeting in Moscow, the Germans

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13. At other times he referred to it as "Wissenschaftlicher Rat" or "Technischer Rat".

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stayed in the guest house in Ozery, which had been their transient quarters before their transfer to Agudzeri. Also, this waiting period was used [ ] to discuss supply problems at the Ninth Directorate headquarters. 25X1

38. One evening, a caravan of five or six cars brought the Germans and a number of Soviet Referenten from the Ninth Directorate, [ ] Kalashnikov, Barshevskiy, and Leypunskiy, from Ozery to the headquarters of the First Chief Directorate located near Lermontovskaya ploschad. The Germans were ushered into a room in which between 40 and 50 Soviets were gathered around a conference table. Extra chairs lined the walls. the atmosphere was informal and convivial, and the Germans were asked to partake of the refreshments, of which a bountiful supply was available. 25X1
39. The Germans took their seats at the end of the table, with the Referenten of the Ninth Directorate taking chairs to the side and behind the Germans. At the other end of the table sat the presiding official Boris Ilyich Vannikov, who had been Minister of Munitions. His exact title at the time of the 1946 conference was not known [ ] but it was evident that he held the highest rank, even exceeding that of Minister of Chemical Industry Mikhail Georgiyevich Pervukhin. Sitting with Vannikov at the head of the table were Kurchatov and Zavenyagin, both seemingly functioning in the role of co-chairmen. 25X1
40. Some of the Soviets were dressed in civilian clothes and others in military uniform. The uniforms represented [ ] only the MVD. The following were represented: 25X1

Non-MVD Governmental Agencies

Vannikov - Agency unknown  
Pervukhin - Minister of the Chemical Industry  
Mykhnev - Adjutant to Beriya

Academy of Sciences [ ] 25X1

Kurchatov  
Kikoin  
Frumkin  
Ioffe

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Academy of Sciences - cont'd

Alikhanov  
 Vekshinskiy  
 Flerov, Georgiy N.  
 Vinogradov, Aleksandr Pavlovich  
 Artsimovich

MVD-Ninth Directorate<sup>15</sup>

Zavoryagin  
 Leypunskiy  
 Kalashnikov  
 Barshevskiy

41. The pleasantries completed, the Soviets asked Hertz to report on the activities of all Agudzeri departments, except mass spectroscopy, and von Ardenne to report on the activity of most of the Sinop departments. The remaining Germans reported on their specific projects. After the completion of each recital, there were a number of questions by the Soviets and discussions among themselves.

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the occasional flare of tempers. that there did occur disagreements

42. When Hertz, who was the first of the Germans to report, was finished, Thiessen reported about the Sinop work on barriers. Upon completing this report, he wanted to elucidate on his corrosion experiments, but was told by the Soviets that this was of no interest to this group and should be discussed separately.

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Thiessen afterwards had numerous conferences at the Ninth Directorate, and suspects that corrosion problems were then discussed.

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15.

the FOD entered the picture relatively late (i.e. 1949), no attempt is made here to differentiate between the two organizations.

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44. Von Ardenne reported next, [redacted] on the whole the Soviets seemed satisfied. Steenbeck was the last to report and had little to say, since his work had only recently commenced.

45. [redacted] the interest of the individual Soviets represented at the Council [redacted]

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Hertz's Recitation	: Kikoin, Ioffe, and an elderly but unidentified Soviet.
Thiessen's Recitation	: Kikoin.
Source's Recitation	: Leypunskiy, Alikhanov and Kikoin (in the order listed).
Von Ardenne's Recitation	: Primarily Artsimovich, but also Leypunskiy, Alikhanov, and Kikoin.
Steenbeck's Recitation	: Kikoin.

46. Conspicuous by their non-participation in the discussions were Vinogradov, Flerov and Frumkin. Of the first named, [redacted] he did not seem to be concerned with any of the work performed by the Germans, but evidently was working in an atomic field completely divorced from those discussed. When the recitals were completed, the Germans together with the Referenten

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16. It was, however, not until 1950 that [redacted] received Soviet electrometer tubes, which were copies of the FP 54; but the electrodes were fabricated of such soft metal that short circuits existed between grid and plate.

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of the Ninth Directorate, Barashevskiy and Kalashnikov, left. Upon leaving, a number of unidentified Soviets, armed with charts and drawings, waiting in the corridor for their turn to appear before the Council.

47. the Germans appeared to have made, on the whole, a satisfactory impression at the conference, and that the Soviets were very much impressed, particularly by Hertz's work, in spite of the fact that neither had as yet been successful when working with uranium.

48. The Germans had been prepared to give proposals for the coming year's work at the council meeting. Instead, conferences dealing with next year's work were held, in the days immediately following the Scientific-Technical Council meetings, at Zavenyagin's office at the Ninth Directorate headquarters building. All the Germans as well as the Ninth Directorate Referenten were present. The assignments for 1947 were the following:

a. Hertz's Assignment .

Hertz was put under some pressure to drop his experiments with light model gases and to redesign his pump device so as to begin immediately with uranium-isotope separation. Hertz would have preferred to continue the light model gas experiments, as he felt that he did not as yet know enough about their properties. The Soviets were already beginning to develop some of the impatience which later characterized their attitude toward Hertz.

Hertz began uranium work before a really sound basis for these experiments had been obtained that the unsatisfactory results later obtained may have been in part the result of this fact.

b. Schuetze's Assignment

As in the case of Hertz, the Soviets pressed him to begin immediately with uranium measurements, even though he was not as yet certain that the apparatus would function even with light elements. The Soviet insistence in this case was more reasonable than in the case of Hertz, however, since during the Council discussion source had even gone so far as to pretend that he had been working with uranium, whereas in reality he had been primarily experimenting with carbon dioxide. In this connection, it is noteworthy that his Soviet assistant Ketevana Grigoryevna Ordzhonikidze, though aware of his deceit, did not expose him.

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## c. Von Ardenne's Assignment

As if to emphasize once again the need for mass spectrometers, von Ardenne and Rach Aramovich Demirkhanov were ordered to build a mass spectrometer and also an efficient ion source for the electromagnetic separation of uranium metal.

## d. Hartmann's Assignment

Hartmann was to continue the design of an alpha counter which would measure changes in the isotopic concentration of uranium, obtained by the countercurrent method, with an accuracy of one percent.

## e. Reichmann's Assignment

Reichmann was to continue work on barriers but to use nickel instead of copper.

## f. Thiessen's Assignment

Thiessen was to make corrosion studies, to work on barriers, and to make isotope-separation studies coupling gaseous diffusion with the elusion method.

49. During the years 1947 and 1948, [redacted] 25X1  
[redacted] the Scientific-Technical Council [redacted] meetings 25X1  
remained the same, as did the agenda; namely, reporting on past activities and making proposals for future work. The composition of the Soviet members of the council varied only slightly, and [redacted] 25X1  
[redacted] only that Vannikov did not participate in meetings after 1946. The procedure, too, underwent a slight change. In the first meeting, all Germans were in the conference room throughout the recitations by Germans, but in later years only Hertz sat in from beginning to end, while the other Germans entered the room only in order to make their reports. [redacted] 25X1

50. In the year 1949, probably no Germans from Agudzeri attended the meeting, as the leading Germans were either in Verkhniy Neyvinskiy or had just returned from there. It is possible that von Ardenne and Steenbeck from Sinop attended the Council meetings. [redacted] 25X1

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51. In connection with proposals for the coming years work made by the Germans to the council, it should be stated that on the whole the Germans in Agudzeri and Sinop usually made proposals that were a natural extension of their development work within the over-all project. These proposals were generally approved without any alterations by the Scientific-Technical Council in Moscow. The plans for the coming year were drawn up a week or two before the Council meeting, and each German made reference to his future work in the recitations before the council. These remarks were usually perfunctorily passed over by the council. By February of the following year, the official plan came from Moscow and hardly ever diverged from the German proposal. As a matter of fact, it soon became a custom in Agudzeri to begin January's and February's work as if the proposals had been approved.

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HIGHLIGHTS FOR THE YEAR 1947Mass Spectrometric Activity

54. During the year 1947, [ ] stopped work on the first model mass spectroscopy and completed the mass spectrometer and first uranium measurements. [ ]

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55. [ ] if one measures the natural uranium-isotope ratio in a source immediately after measuring a sample containing 50 percent  $U_{235}$  an error of about 10 percent will be made in the measurement of the former sample. After one hour the memory effect is only one-half percent. In order to completely remove the memory effect by simply pumping out the system, several days are required. [ ] flushing out the source with  $UF_6$  for one hour was equivalent to a day's simple pumping-out. If the instrument was baked out for several hours, the memory effect was removed.

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56. The highlights of [ ] on mass spectroscopy during the year can best be seen in reference to two commissions which indicated the urgency of the work at this time from the Soviet point of view:

Whip Commission, Spring 1947

57. During spring 1947, or possibly during February, Zavenyagin with an unidentified Referent from the Ninth Directorate, paid a brief visit to Agudzeri. He made a cursory inspection of each department and then expressed his disappointment in the work of the Germans to the director, Prof. Hertz. [ ] This sentiment surprised the Germans who only a few months earlier had been praised by what they thought was one of the highest atomic-energy committees in the USSR. In retrospect, [ ] Zavenyagin, who knew that a high governmental commission was about to inspect Sukhumi for the purpose of exhorting the Germans to greater effort, had rushed to Agudzeri in order to warn the leading Soviets there, particularly Gen. Kochlavashvili who represented the link between the Ninth Directorate and the two Sukhumi institutes. Zavenyagin did not warn the Germans of the approaching storm.
58. Shortly after Zavenyagin's whirlwind visit, a Soviet commission arrived by plane at the old military base in Eshery [N 43-03, E 40-55] and took up residence at the State Dacha No. 6 in the former botanical garden of Sukhumi. One evening, Hertz, Barwich, Hartmann, Reichmann,

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Bumm, and source were ordered to appear. This group was joined by Thiessen, as the only Sinop representative. The presiding officer was Pervukhin. Vannikov, who had headed the 1946 Council meeting, was not present; and Pervukhin may, at this time, have assumed control over the entire Soviet atomic energy project. Other members of this meeting, which lasted from 2300 to 0200 hours included Kurchatov, Alikhanov (representing the Academy) and possibly [B.A.] Malyshev, who later became Minister of Medium Machine Building. 25X1

59. All Germans appeared at the same time and gave a report on their work. Unlike the meeting in Moscow, however, the Soviets were most unsympathetic. No sooner had the first German completed his recital than Pervukhin set the tenor for the evening with biting criticisms. The other Soviets followed suit, and none of the Germans were spared as the Soviets even assumed hostile attitudes. 25X1

a. Hertz reported on isotope separation and theoretical calculations for the countercurrent-diffusion method. There followed a lengthy discussion between Hertz, Barwich, and the Soviets which assumed fairly vehement proportions, especially on the part of Pervukhin. The latter pressed Hertz to state the energy requirements he had estimated for the countercurrent-diffusion method. Hertz answered that his work had not sufficiently progressed to make such an estimate. As ordered by the Council, he had dropped the work on light elements and had begun with uranium but had been without success. The separation factor was still practically zero. Hertz made no effort to confound this issue. Still Pervukhin remained adamant, whereupon Hertz, in order to prove the inadequacy of his development work up to this time, cited a requirement of the order of  $10^9$  kilowatt for 1 kg  $U_{235}$  per day. Pervukhin was absolutely confounded and considered the answer a personal insult. He accused Hertz of being an "impractical, ivory-tower figure who was divorced from all realities and who had no conception of magnitudes." Evidently, Pervukhin had not understood that Hertz had quoted this magnitude only in order to show how meaningless it was to estimate on the basis of the results thus far obtained. None of the other Soviets present dared or took the trouble to correct Pervukhin's misconception.

- b. The tenor having been set in the Hertz interview, the Soviets continued in the same vein to find fault with the work of the other Germans. Thiessen, Bumm, and Reichmann were asked to report on their barrier development. 25X1
- the Soviets referred to Reichmann's work as a "conglomeration of fuzziness." 25X1

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d. Hartmann was mauled least by the Soviets. His alpha counter was finished and he had obtained quite successful results. In this connection, only the needed materials and possible suppliers were considered for a small series of alpha counters that Hartmann was to begin producing in Agudzeri.

60. [redacted] from the atmosphere in which the commission met, from 25X1 the behavior of the commission members, and from the unrealistic arguments coupled with spurious accusations, that the entire affair was staged in order to intimidate the Germans and force them to more concentrated effort. The Soviets were not interested in valid explanations and in finding the true causes for the impediments to the

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development. They had come to find fault with the work of the Germans. Only a few months earlier, the Soviets seemed impressed; now they showed for the first time their mailed fist.

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61. It is also possible that the Soviets expected the Germans, who had unquestionably made mistakes, to express "socialist self-criticism." This they did not do, and it is also possible that some of the Germans may have been inclined to defend what were, on the whole, untenable positions.

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This incongruity again emphasized the complete absence of rationality evidenced by the commission and underscored the fact the commission primarily served to intimidate the Germans. On another evening, the commission took to task the leading Germans in Sinop. The routine was evidently the same, and the Sinop personnel fared no better, although details were not known.

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#### Zverev-Leypunskiy Investigation in Agudzeri

62. A few months after the whip-commission headed by Pervukhin, probably towards the middle of 1947, MVD Gen. Zverev (fnu), deputy to Gen. Zavenyagin, and Leypunskiy, the (measuring) Referent of the Ninth Directorate, arrived in Agudzeri where they stayed for a period of three months. They were in Agudzeri for but one purpose. Each morning, Leypunskiy studied the progress on the mass-spectrometer development. He looked over shoulder as he performed theoretical calculations, but since Leypunskiy seemed to understand little of the theory he concentrated on the technical aspect of the work. He listened instructions to his German and Soviet assistants and participated in experiments.

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64. continually complained that the materials were at fault, the Soviet investigators took drawings of cooling traps and vacuum tubes to Sinop for construction in those workshops. When these were tested in Agudzeri for vacuum tightness, they were no better than the inferior ones that had been made in Agudzeri. It was simply impossible to obtain iron tubes that could be hard-soldered or welded without having them burst when cooled to the temperature of liquid air.

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65. When an experiment conducted [ ] during the day had failed, Zverev 25X1  
ordered the Soviet assistants to repeat the experiments again at night.  
Long into the nights, experiments would be repeated but with the same  
negative results. [ ] 25X1

66. It seems that Zverev and Leypunskiy were now convinced that the trouble 25X1  
actually was one of faulty supplies, for Zverev assured [ ]  
improved equipment would soon arrive. Indeed, shortly after their  
departure such shipments did arrive, which included:

Mercury diffusion pumps: approximately 50. [ ] probably 25X1  
at the A.Z.A. plant.18

Copper tubes : approximately one ton of diverse diameters.

Steel tubes : approximately one ton of diverse diameters.

German silver tubes : approximately one-half ton for use by Reichmann.  
(All these tubes came from German booty supply  
dumps and not from the current German production).

Receiving-Inspection Commission, Fall 1947

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67. Tubes and pumps were the items that had stood between [ ] the 25X1  
successful mass spectrometer, and with the vacuum problem finally solved  
the project soon showed signs of success. The electrometric problem had  
been solved even prior to Zverev and Leypunskiy's investigation, when

[ ] 25X1  
in 1947, there also had arrived a shipment of about 200 to 300 US RCA  
Acorn 954 tubes from a Soviet Air Force supply depot.

18. [ ] these pumps were obtained by Irakliy Kirvalidze, 25X1  
a Soviet at Sinoj [ ]  
[ ] the Soviets always pressed [ ] to use oil diffusion  
pumps because they were then being manufactured in the USSR.

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68.

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The following year the first technical mass spectrometer left for NII-160 for mass production.

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69. During August or September 1947, a receiving-inspection commission headed by Popov (fnu) of the Ministry of Communication Equipment Industry and including members from the Ninth Directorate, NII-160, IRPA [Institut radio priyema i akustiki - Institute of Radio Reception and Acoustics], the Institute of Vacuum Problems, and Laboratory 2 arrived.

ordered to make two more mass spectrometers, and it was decided that the first of these mass spectrometers was to go to Verkhniy Neyvinskiy and the second to NII-160. Later when the mass spectrometer was completed, this decision was reversed, and the first mass spectrometer was sent to NII-160 in Fryazino.

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the time-table for the gaseous diffusion plant in Verkhniy Neyvinskiy was behind schedule.

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#### Meeting of the Scientific-Technical Council

70. Scientific-Technical Council during December 1947.

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The council only confirmed the earlier orders for two more mass spectrometers to be constructed during 1948, and deadlines were set. The council also inquired as to his supply needs. These were copper wire for the magnet and a precision voltage divider for the high-voltage supply.

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#### HIGHLIGHTS FOR THE YEAR 1948

##### Summary of Mass-Spectrometric Work

71. During the year 1948, the laboratory was occupied with the construction, testing, and operation of the mass spectrometers of the type which had already been developed. No new developments were initiated during this period. Training of personnel from Verkhniy Neyvinskiy was also carried on during this period.

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Mass-Spectrometer Receiving-Inspection Commission

72. During the year 1948, two mass spectrometers were completed referred to as MS-1 and MS-2. The mass spectrometer completed during 1947, and which was a laboratory model was numbered MS-0. 25X1
73. When the first mass spectrometer MS-1 was completed a receiving-inspection commission arrived in Agudzeri. 25X1  
it consisted of engineers from NII-160, Fryazino, and from IRPA in Leningrad, and was headed by Popov of the Ministry of Communication Equipment Industry who, however, did not arrive until the tests were completed in order to sign the necessary protocol. Unlike the first commission, tests were not made with enriched UF<sub>6</sub> but rather with samples obtained from Hertz's experiments. Comparative tests were made with the laboratory-model mass spectrometer and then with Hartmann's alpha counter, and it was found that the new apparatus had exactly the same properties as the first laboratory model.
74. Prior to the arrival of Popov, the Soviets were disposed to criticize many minor aspects of the mass spectrometer. It seemed that the commission was eager to suggest "improvements" - mostly in the nature of cost cutting. It was also evident that by evaluating work as low as possible the Soviet contributions would appear magnified, and thus might result in premiums for the Soviets. Since they did not have confidence in their own technical ability, however, they dared not tinker with the ion source, collector, or electrometer amplifier. They did suggest simplifying the cooling traps or other parts of the vacuum system. Typical was the proposal that the base of the mass spectrometer should be oblong instead of square. 25X1
75. In one connection, their questions might give an insight into probable technological difficulties the Soviets might have encountered in the mass-spectrometer construction. They had had no experience whatever with metal gaskets, and considered the metal vacuum gaskets used by source in the design as "uncanny." They feared that metal gaskets could not be used in industry, where the precision work of the laboratory was not possible. Source showed them the method used by him to make interchangeable flanges. Later, NII-160 personnel was happy to find that upon applying his technique the metal gaskets were at least as secure as rubber gaskets. When the final protocol was drawn up, Popov stated that the design had been inspected and was ready for immediate copy, by IRPA and NII-160, for a small zero-series. Shakhov (fnu) and Meyzerov (fnu) representing NII-160 and IRPA respectively still argued that the design was a laboratory model and not a technical design. Popov energetically warded this off, stating that the only changes that were required were of an architectural nature and warned the two groups against making independent changes. The final protocol 25X1

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contained a clause that in the event any change was contemplated in the process of manufacturing, permission would first have to be obtained [redacted]. The MS-1 was then transported to NII-160. It was accompanied by all the applicable drawings and descriptions of all parts and explanations of every technological process involved in the construction, including the soldering process and the requirements for cleanliness. The stage arrived at, when the machine was transferred, was equivalent to what in Germany would be a zero-series, that is, a transition stage halfway between laboratory drawings and production drawings.

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#### Disposition of Mass Spectrometer MS-2

76. While the second mass spectrometer MS-2 was being assembled, the two Soviet technicians Glukhov (fnu) and Kliščernyy (fnu) arrived from a supersecret installation later identified as Verkhniy-Neyvinskiy. They assisted in the final assembly and familiarized themselves with the operation of the mass spectrometer. Finally, a protocol was signed without a prior examination of the machine by a receiving-inspection commission. It was then crated and taken by Kliščernyy and Glukhov under special guard to an unknown destination. This machine was one of two [redacted] in Verkhniy-Neyvinskiy, [redacted] performed enrichment measurements at the gaseous-diffusion plant in fall 1949.

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77. [redacted] no further commissions or high-ranking visiting dignitaries in Agudzeri during the year. [redacted]

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[redacted] From then on, the work consisted merely of the routine construction of additional mass spectrometers. When [redacted] finished with one, [redacted] generally ordered by Gen. Kochlavashvili to build two more. The exact procedure involved in the issuance of assignments by higher Soviets levels was not known [redacted]

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#### Meeting of the Scientific-Technical Council, December 1948

78. As in earlier years, Hertz, Barwich, Thiessen, von Ardenne [redacted] were flown to Moscow to report on their activities to the Scientific-Technical Council in the First Chief Directorate Building on Lermontovskaya ploshchad. [redacted]

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79. Of the entire meeting, [redacted] Hertz and Barwich were quite apprehensive because of the absence of success in their experiments with countercurrent diffusion.<sup>21</sup> According to statements made by Hertz to source, the former could not understand the Soviet dissatisfaction, since he (Hertz) had given precise reasons for the failures, i.e., the corrosion problem with the liquid fluorocarbons. [redacted] it was around this time that Hertz had come to the conclusion that there was simply no solution to his problems in countercurrent diffusion. Barwich, who was wont to say of the machinery that "it belonged in a museum," also is believed [redacted] to have told the Soviets that continued efforts were in vain, and that they were placing too much hope in the Hertz apparatus. The Soviets then told Barwich that it was his task to assist Hertz and they indicated that he might have been deliberately withholding his help. [redacted] these exchanges occurred at the Scientific-Technical Council meeting in 1948, and [redacted] Barwich was around this time fearful of being accused of sabotage.

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80. In connection with the Hertz experiments with countercurrent diffusion, [redacted] It appears that as early as 1948 Hertz had actually begun to lose faith in being able to find a solution to the project. Yet the Soviets on the Moscow level always pressed for a continuation of the work. The Soviet scientists in Agudzeri working with Hertz, namely, Irakliy Gverditsiteli, Popov (fnu), and to a lesser extent [Oleg] Poroshin, were on the other hand always in favor of pushing on with the experiments. They grasped at every straw, and whenever the results showed an improvement, however small, they were jubilant. In their enthusiasm, they were irresponsible and in reporting to Hertz experimental results, they tended to exaggerate their success. For example, they stressed the significance of stray and higher readings in a series of measurements. Poor results were often laid at the door of the measuring departments by these Soviet assistants, and after a while Hertz had become so upset that he was inclined to believe that his failure resulted from [redacted] Hartmann's inability to measure his samples.

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81. [redacted] very likely that Moscow's insistence upon continued work in the face of Hertz and Barwich's pessimism was to no small extent the result of separate and glowing reports by these Soviet assistants of Hertz. The likeliest explanation for the action of these assistants was that they were blinded by the possibility of honors in the form of Stalin Prizes and premiums. [redacted] they certainly did not have the scientific knowledge to come independently to a conclusion on the merits of the countercurrent method.

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21. [redacted] there is no doubt that there was one meeting at which Hertz and Barwich exhibited this fear and at which they were taken to task about the absence of success [redacted]

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82. Finally [redacted] frequent attacks by Hertz's assistants by having a series of 100 samples from Hertz's experiments especially checked again in Hartmann's laboratory. A comparison of the results showed that the measurements of both sections had been accurate.

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#### HIGHLIGHTS FOR THE YEAR 1949

##### Disposition of Mass Spectrometers MS-3 and MS-4

84. In spring 1949 (March or April) the third technical mass spectrometer (MS-3) was completed. Klishterny arrived from the then still super-secret Verkhniy Neyvinskiy installation, and departed with the crated machine. About the same time, Zadorozhniy, a representative from the Academy of Sciences' Geo-Chemical Institute headed by Vinogradov, arrived. Zadorozhniy was, in the opinion of source, a departmental chief in charge of the mass-spectrometric work in Vinogradov's institute. He worked [redacted] for about two months studying the assembly and operation and then departed together with the machine (MS-4) during either June or July 1949. Of prime significance in connection with this mass spectrometer was that the machine was not to be tested with  $UF_6$  in which Zadorozhniy expressed no interest whatever. Only carbon dioxide was measured in order to demonstrate the measuring accuracy of the mass spectrometer. Special care was taken to adjust this machine in the vicinity of the mercury spectrum. The impurity lines in the vicinity of the mercury spectrum were carefully studied, as were methods for good bake-out procedures and for the determination of the minimum obtainable mercury intensity. In removing the mercury spectrum from this mass spectrometer, some difficulty was encountered because of the two isobars with nuclei of mass 204 (mercury and lead isotopes). After careful adjustment, it was possible to record lead-204 with an accuracy of one percent.

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85. [redacted] the Vinogradov institute planned to use the mass spectrometer in order to determine the isotopic composition of lead found in uranium minerals in order to determine the age of uranium deposits. That lead studies were made in this institute was evident in 1950 or 1951, when the institute published a work giving the isotopic composition of common lead. 25X1

86. [redacted] the only logical explanation for giving the high-priority machine to Vinogradov's institute was that this institute was engaged in, or possibly directing, the Soviet uranium prospecting program, and that this was an activity of great importance to the Soviets at that time. 25X1

[redacted] Zadorozhnyi had built, prior to World War II, a copy of the original Bainbridge-Jordan mass spectrograph. During the war the work had been discontinued, and while resumed after the war, Zadorozhnyi was still encountering difficulties with this mass spectrograph. 25X1

#### Visit to NII-160

88. During the beginning of October, [redacted] ordered to NII-160, allegedly to inspect the first mass spectrometer which had been completed by that factory. The receiving-inspection commission consisted, of [redacted] Popov of the Ministry of Communications 25X1

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Equipment Industry, and an unidentified representative of the Ninth Directorate, [ ] he worked in an Academy of Sciences installation on mass spectroscopy.

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[ ] Soviet assistants from Agudzeri, Ketevana Grigoryevna Ordzhonikidze and Aleksandr Bolotnikov sitting in front of a mass spectrometer. These two had left Agudzeri on a komandirovka (official travel orders) about one month earlier.

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[ ] they had evidently been sent there to assist in the final adjustments of the machine and/or to participate as members of the receiving-inspection commission. Another [ ] assistants, Aleksandr Sinyavskiy, too, had been in NII-160 for a short while and for the same purpose.

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89. At this time, despair reigned among the Soviets, as it was evident that they had not been able to get the mass spectrometer to function. A brief inspection revealed the following: the vacuum was poor, a pressure of only  $10^{-6}$  mm mercury was obtained, and all lines were multiplied at least twenty times. For example, the mercury spectrum, instead of six lines, exhibited about one hundred lines. It appeared that the Soviets had once recorded a correct mercury spectrum and had hastily summoned the receiving-inspection commission; but when the commission arrived, the machine no longer operated; not even the carbon dioxide, much less a uranium-isotope spectrum was being recorded.

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90. The mass spectrometer was essentially a duplicate [ ] Agudzeri model.

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[ ] this machine had been constructed with Soviet parts only. The translation of [ ] German norms to Soviet industrial norms had been performed in NII-160, but with the proviso that [ ] approval was required before any changes could be made. It was found that the NII-160 model did contain a number of changes. For example, the electrometer housing was connected to the spectrometer tube in such a manner that it did not have proper cooling, and thus the high resistances burned out. [ ] the cooling traps were incorrectly built. The control device for the ion emission had been simplified with the result that the ion current oscillated. In addition, NII-160 was hard put to explain to Popov these changes for which no prior approval had been received [ ] and they were forced to return to [ ] old design.

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91. The principal fault, however, was one of vacuum. [ ] the Soviets had installed the pumps as they had come from the factory without first cleaning them, thinking that they would automatically emit the impurities during the pumping process. For about ten days, [ ] supervised the disassembly of the machine, the cleaning of pumps and spectrometer tubes, etc. [ ] ordered the highest possible bake-out temperature, and while the Soviets were fearing the worst for their hard-solder and glass-metal joints, the mass spectrometer was subjected to a temperature of 500°C for twelve hours.

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The vacuum was greatly improved, reaching below  $10^{-7}$  mm mercury, which was the limit of the manometer, and the mercury spectrum now consisted of the orthodox six lines of correct intensity distribution. A receiving-inspection protocol was then drawn up, containing findings and recommendations to insure faultless assembly in the future.

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Scientific-Technical Council Meeting, December 1949

96. No German specialists from Agudzeri attended the 1949 meeting of the Technical Council in Moscow as the leading scientists were still in Verkhniy Neyvinskiy or had just returned therefrom. It is very likely,

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however, that Steenbeck and von Ardenne of Sinop attended the meeting,

In the period from 1950 to 1952  
von Ardenne, Steenbeck, and Thiessen of Sinop  
and Hertz and Barwich of Agudzeri attended council meetings

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# HIGHLIGHTS FOR THE YEAR 1950

## Visit to NII-160, Spring 1950

97.

For test purposes, natural UF<sub>6</sub> was delivered to NII-160 by Golovin

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the electrical equipment for these two types of machines was furnished by IRPA in Leningrad, whereas the vacuum parts were made and the assembly was performed in NII-160. This work was under the direction of Popov of the Ministry of Communications Equipment Industry.

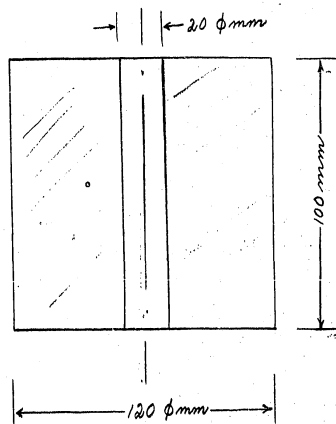
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98.

the magnetic cores used in the helium leak detectors were supplied by NII-628. This installation was near Moscow and was headed by the metallurgist Seymovskiy (fnu). later was supplied by NII-628 some identical magnetic cores for use in his gas analyzer. These cores were very similar to the American commercial product "Alnico 4", and their dimensions were as given in sketch below. The alloy carried the Soviet classification "Magniko-628" which was imprinted on it.

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Disposition of Mass Spectrometers MS-5 and MS-6

99. During 1950, the mass spectrometers MS-5 and MS-6 were completed in [redacted] in Agudzeri. These machines were not inspected by receiving-inspection commissions, and upon their completion they were sent to unknown destinations. [redacted] it was in connection with one of these two machines that a Soviet by the name of Shcherbin (fnu) from Artsimovich's laboratory arrived to collect the machine [redacted]. Since these two machines were completed relatively early, [redacted] instructed by Gen. Kochlavashvili to begin on two more mass spectrometers, MS-7 and MS-8.

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Hot-Anode Ion-Source Development

100. Also during 1950, [redacted] auxiliary experiments on the automatic gas analyzer. He experimented with oil diffusion pumps in order to study the final vacuum and the residual impurities in the pumps and other operating conditions of the oil diffusion pumps. Then also, source experimented with Freon-compressors which were to be used as an automatic cooling device for the cooling traps of the analyzer.

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On these strips were deposited 20 to 50 milligrams of uranium. Nine strips were found to be enriched to between 30 and 40 percent concentration with a mean concentration of around 35 percent.<sup>22</sup> The deposit on the tenth strip contained less than 0.1 percent  $U_{235}$ .

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in connection with this measurement the samples were to be measured without first being chemically treated or converted, that is, the material was to be taken directly from the strips and measured with the hot anode. This requirement source was unable to fulfill because of excessive contamination by zinc, nickel and iron. extracted the uranium and converted it to uranium nitrate which he placed directly into the ion source. After the measurements, the samples remained in his laboratory and were never called for again in spite of previous security warnings issued by Gen. Kochlavashvili.

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103. The sample tests confirmed that the new ion source was developed for a Soviet electromagnetic-separation group, as the strips unquestionably originated with such a group. Another factor supports this conjecture. The new ion source was to be built in exactly the same manner as the originally supplied ion source, so that they could be used interchangeably on his mass spectrometers. One of the mass spectrometers completed during the year 1950 was sent to an electromagnetic-separation installation.

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#### HIGHLIGHTS FOR THE YEAR 1951

##### Disposition of Mass Spectrometers MS-7 and MS-8

104. The mass spectrometers which were started the year before were completed by mid-1951. Neither was inspected by an inspection-receiving commission and both remained in Sukhumi. MS-7 remained to be used in connection with Hertz's experiments. MS-8 was constructed with the aid of personnel from Steenbeck's laboratory in Sinop, and after completion was sent to Steenbeck. The following year this model was returned to Agudzeri, as Steenbeck's department was unable to cope with it.

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##### Gas-Analyzer Commission, June 1951

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105. On at least two occasions, Chekhovtsov in Agudzeri who in 1949 was transferred to Verkhniy Neyvinskiy, visited Agudzeri and carefully studied the progress on the automatic gas analyzer. on these occasions Chekhovtsov had built his own analyzer in Verkhniy Neyvinskiy, but that it made use of mercury diffusion pumps and liquid air traps, and thus was very much out of line with Kikoin's automatism requirements. ten of these analyzers were built by NII-160, but that it had been decided to drop the production.

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22. At another time, all nine strips were enriched to exactly the same degree,

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106. [redacted] the experiments with the gas analyzer [redacted] was abruptly interrupted by the arrival of a commission which had the task of inspecting the project. This commission consisted of Chekhovtsov from Verkhniy Neyvinskiy, Shakhov from NII-160, Meyzerov from IRPA, and three others from unidentified installations. It was planned that other Soviets would arrive in Agudzeri from Moscow, if the preliminary inspection was satisfactory. In this connection, Popov of the Ministry for Communications Equipment Industry, was mentioned. The action and demeanor of this group was very much different from other commissions with which source had dealt in the USSR, and [redacted] 25X1
- [redacted] the commission aimed, and possibly had been instructed, to throttle the work on the gas-analyzer project. Immediately upon arrival, the commission [redacted] had not as yet prepared any written material for the analyzer and with some ill-humor demanded a detailed verbal report. In this report, [redacted] 25X1
- [redacted] stressed in particular the difficulties resulting from the absorption and the exchange effects, and possibly even exaggerated them somewhat so as not to awaken false hopes. The report was received in silence. A few hours later, Chekhovtsov presented an "opposition report" to the commission, from which meeting all members [redacted] 25X1
- [redacted] Chekhovtsov branded [redacted] report as incomplete and in part incorrect. He also briefly cited results which he had obtained with his own gas analyzer in Verkhniy Neyvinskiy; for example, he asserted that it was absolutely necessary to measure free fluorine and water in addition to HF, F<sub>2</sub>O, CF<sub>4</sub> and air. His reason was that these impurities appeared in the cascade as admixtures of UF<sub>6</sub>. 25X1
107. The commission then demanded that a measurement of a mixture of HF and F<sub>2</sub> be demonstrated on the gas analyzer, in order to determine the measuring accuracy and the delay-effect caused by the absorption phenomenon. [redacted] the fluorine would obviously destroy a machine operating with oil diffusion pumps. In a letter to the director of the Sukhumi institute, he officially went on record as opposing the experiment, and cited the reason among others that it was not possible that pure fluorine could exist in the cascade, and that its alleged occurrence was the result of a measuring error. The commission thereupon obtained a telegraphic order, allegedly from Moscow, insisting on the immediate execution of the experiment. This order was transmitted to source through Gen. Kochlavashvili. [redacted] refused to carry out the experiment, whereupon the general ordered the experiments to be performed by Chekhovtsov and [redacted] Sinyavskiy. The result was that upon the first injection of fluorine the needle valve became clogged. When it was opened still more and far past the normal position, the valve suddenly permitted a relatively large quantity of fluorine to enter the system and the anode burned through. This ignited a glow discharge within the ion source and the pump's oil reacted with the mixture of gases. Since the needle valve could no longer be 25X1

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closed, air was let into the analyzer from the prevaacuum side with the aim of stopping the reaction with the continuously in-rushing fluorine. This sealed the fate of the analyzer. The commission drafted the final protocol and then departed in a state of depression. Although Kochlavashvili implied that this affair would have repercussions for Chekhovtsov, the latter was honored with a Stalin Prize a year later.

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108. The apparatus was then repaired, even though the director of the institute disclaimed any further interest in the machine from the Soviet side. It was discovered that the steel needle of the needle valve had been completely corroded. The repaired apparatus was turned over to the Hertz laboratory, where it was successfully used for numerous experiments until 1955; at times it was in operation for weeks at a time. In fact, Hertz is supposed to have stated that it was the only instrument on which his neon-mixture separation experiments could be successfully carried out.

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110. In 1954, the cannibalized gas analyzer, devoid of ion source and associated electronic equipment including high-voltage units, was returned from Verkhniy Nayvinskiy to Agudzeri where it was officially expunged from the inventory. It is interesting to note that, while the Soviets were ordinarily very strict in inventory matters, the returned gas analyzer was treated most liberally, and the director gave his signature without any lengthy investigation.

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#### Hot-Anode Ion-Source Inspection

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111. The gas-analyzer inspection commission also asked for a demonstration of the ion source [redacted] designed in 1950. [redacted] it was then decided that this new ion source should be introduced into the production program of NII-160, that is, every mass spectrometer leaving the factory was to be equipped with a hot anode as an auxiliary ion source. [redacted] from this time every type of mass spectrometer was equipped with three ion sources:

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- a. Ion source for normal gaseous combinations.
- b. Ion source in which substances could be evaporated and ionized like normal gases.
- c. The new ion source developed for  $U_3O_8$ ; that is, the hot anode.

A new mass spectrometer thus equipped arrived in Agudzeri during 1954, and [redacted] told that this was standard equipment for all mass spectrometers shipped out of NII-160.

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#### Commission at Hertz Laboratory

112. During the year 1951, a Soviet commission visited Agudzeri and inspected the Hertz projects. [redacted] the commission came from Gorkiy, and that engineers from a factory located in that city were members. [redacted] this factory was not identical with the compressor factory headed by Gen. Petrov (fnu) in that city.

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#### Scientific-Technical Council

113. [redacted] Hertz and possibly Barwich of Agudzeri and Steenbeck and von Ardenne of Sinop attended the meeting of the Scientific-Technical Council in Moscow during December of 1951.

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#### HIGHLIGHTS FOR THE YEAR 1952

##### Cessation of Classified Work in Sukhumi

114. By the end of 1951, most of the departments in Agudzeri, with the exception of Hertz's department, had completed their projects which had atomic-weapon implications. No new assignments were given to the German departments. The morale of the German specialists dropped decidedly, and a barrage of letters was written asking more or less firmly that they be returned to Germany. Finally, probably in 1952, Gen. Zavenyagin arrived and informed the Germans that the classified work had ended and that they would henceforth work on projects to be selected with due emphasis upon the preference of the individual scientist. This period was to constitute a "quarantine."

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115. The First Sections in Agudzeri and Sinop were instructed to scrutinize all classified papers and to declassify some, destroy others, and forward the remainder to Moscow. The change-over was finally made complete with the transfer of the remaining classified sections: Hertz to Moscow, and Steenbeck and Thiessen probably also to Moscow or vicinity. About the same time, a number of Germans from other installations in the USSR, e.g., Sungul and Obninskoye, under the leadership of Nikolaus Riehl arrived to spend their "quarantine" in Sukhumi prior to return to Germany.
116. The principal reason for the depression of the Germans was of course their desire to return to Germany. Another reason was a lack of stimulating work and particularly their inability to meet with leading scientists in order to exchange ideas. All felt that they were being stultified in their professional development. To counteract this, the Soviets now instituted a program of colloquia at which German and Soviet scientists from other installations met to exchange their findings.

Mass-Spectrograph Assignment

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117. [redacted] around 1951/1952 [redacted] completion of the [redacted] 25X1  
 ° gas analyzer.° With security restrictions lifted, the Soviets per- [redacted] 25X1  
 [redacted] 25X1  
 [redacted] performed pedagogical functions, as graduate students (mostly from the Tbilisi university) were sent [redacted] they 25X1  
 engaged in experimental mass-spectroscopic work leading towards a degree.
118. The principal task [redacted] 25X1  
 was the development and construction of a large-size mass spectrograph. The suggestion for this development came from the Soviet director of Agudzeri [redacted] 25X1  
 Some theoretical studies for the mass spectrograph were begun in 1951, when [redacted] different methods for focusing of a higher order, with the aim of removing the errors of the second order encountered in most mass spectrographs which had been constructed up to that time. 25X1

Zadorozhniy's Visit to Agudzeri

119. While source was making the above plans for the construction of a mass [redacted] 25X1  
 [redacted] Zadorozhniy sought advice on [redacted] 25X1  
 the organization of a mass-spectrometer section, [redacted] 25X1  
 [redacted] the Vinogradov Institute for Geo-Chemistry at about this time had occupied a new and very large institute building in the Lenin Hills [redacted] 25X1  
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near Moscow. Furthermore, [redacted] it was now planned to organize an Atomic-Weight Laboratory in this institute, and that this laboratory was to consist of a chemical section and a mass-spectrometric section which was to be equipped with a number of mass spectrometers and mass spectrographs. Zadorozhnyi was to head the mass-spectrometric section of the Atomic-Weight Laboratory.

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120. During this visit, Zadorozhnyi suggested to source that he might transfer to the Vinogradov institute, as the work in Agudzeri had ceased to be interesting. He also mentioned that the mass spectrograph [redacted] about to build would be more properly placed at the new institute building than in Agudzeri.

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[redacted] while Vinogradov had approved the idea, Zavenyagin had declined to allow the transfer. Vladimir Vasilyevich Migulin, the director of Agudzeri, corroborated Zavenyagin's role in this affair.

#### Nuclear-Moments Measuring Colloquium

121. Approximately 20 to 30 Soviet scientists arrived in Agudzeri, and after listening to lectures (especially by Hartmann) on Sukhumi institute's work on nuclear-moments measurements, they gave lectures on their own experiments. [redacted] since Hartmann's work had no classified implications this was a trial balloon in an attempt to raise the morale of the Germans and break their former isolation. The colloquium was under the chairmanship of Sukhumi director Migulin. The leading Germans and Soviets from Agudzeri and Sinor participated. Of those coming from outside Sukhumi, [redacted] Smorodinskiy (fnu) a theoretical physicist, from an unknown installation and Lukyanov (fnu) representing an unidentified installation but met [redacted] at the Ninth Directorate. [redacted] from a scientific standpoint nothing of interest developed during the conference, and as an aside mentioned that among the Soviets were some who were amazed to learn for the first time of the existence of two-well equipped German institutes in Sukhumi.

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#### HIGHLIGHTS FOR THE YEAR 1953

#### Mass-Spectrometer Colloquium

122. In the spring of 1953, the second colloquium in the postsecret era was held in Agudzeri. The chairman was Migulin. [redacted] Again, 30 to 40 Soviet scientists arrived, of whom [redacted] the following:<sup>23</sup>

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Lukyanov

From unknown installation

23. [redacted] included in the listing representatives from Laboratory 9 and Semënov, Referent for Sukhumi.

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Smorodinskiy	From unknown installation; specialist in theoretical physics interested in nuclear spin, and measurements of calcium isotopes.
Zadorozhnyi	From institute for Geo-Chemistry.
Rik (fnu)	From RIAN (Radium Institute of the Academy of Sciences)
[Vladimir Iosifovich] Veksler	
Three or four Soviets -	Vekshinskiy's institute for Vacuum Problems.
Talroze (fnu)	From Physico-chemical Institute of the Academy of Sciences.
Meyzerov (fnu)	From IRPA, Leningrad.
Shakhov (fnu)	From NII-160.
Popov (fnu)	From Ministry of Communication Equipment Industry.
Three or four Soviets -	From Artsimovich's institute.
Alekseyev	Mass-Spectrometer specialist, unidentified institute.

Topics discussed by local Sukhumi personnel were as follows:

[Redacted]	
Ordzhonikidze	Mass-spectrometric measurements with lithium.
[Redacted]	
Leontyev	Mass spectrometers using transit-time principle (Laufzeitprinzip) and cyclotron principle and their application in mass measurements.
[Redacted]	

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Demirkhanov

The measurement of initial velocities of ion sources.

Of the visitors, [ ] only the following:

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Talroze

The formation of Anlagerungsionen in ion sources of low pressure. [ ] defined Anlagerungsionen as ions of the  $H_3$  or  $CH_3$  or  $OH_3$  type that are formed by the attachment of ordinary ions to a neutral molecule. Their intensities are proportional to the square of the gas pressure].

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Alekseyev

Stigmatically-focusing mass spectrometers.

123. Smorodinskiy, Lukyanov, and Vekshinskiy's representatives did not lecture. Rik read a paper [ ]

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Vekshinskiy's representatives were particularly interested in [ ] lecture on systematic errors, and there followed long discussions on the supposed accuracy of his measurements.

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[ ] significant aspects of the meeting

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- a. It was evident that the Soviets had started their mass-spectrometric development, but they still did not have much experience in this field. They seemed to follow the direction of Western developments but were a number of years out of phase. They were making their first fumbling independent researches. It was also evident that NII-160 had finally furnished mass spectrometers to a large number of Soviet installations.
- b. The representatives from Artsimovich's institute were much surprised by the lithium experiments carried out in Agudzeri [ ]
- c. Lead measurements were being made by Zadorozhnyi.
- d. Rik, who seemed to be the director of a mass-spectrometer department at RIAN and had published a text book on mass spectrometry based primarily on US material, performed argon and calcium measurements.
- e. Talroze, who had a mass-spectrometer laboratory with several mass spectrometers at the Physico-Chemical Institute, dealt with problems of hydrocarbons and other chemical analysis.

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Visit by Artsimovich

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124. Some months after the mass spectrometer conference, and still in the year 1953, Artsimovich visited Agudzeri. [redacted] Artsimovich headed an institute of the Academy of Sciences but did not know its designation. It seemed [redacted] that Artsimovich had become interested [redacted] having been informed by his assistants about the lithium experiments. He was awed by the results obtained with [redacted] hot anode when used in measuring lithium. [redacted] Artsimovich was specifically interested in measuring the enrichment grade of separated lithium samples. Artsimovich asked how large the quantity required for measurement is, and whether traces of lithium 7 and lithium 6 could be found in the sample, if very pure lithium 6 or 7 is to be measured. 25X1
125. Up to this time, Artsimovich had frequently been mentioned in connection with the work of von Ardenne, whom he visited several times during the first five years after the war. On one such occasion (probably in 1948), he also visited Agudzeri and discussed problems with source. This visit was incidental to the inspection of von Ardenne's work. Artsimovich discussed [redacted] problems of measuring uranium enrichment, that is, problems concerned with ion-source development and particularly the evaporation of metallic uranium from different crucibles and the evaporation of uranium-tetrabromide and other compounds. He also asked [redacted] whether he was familiar with the work on strong focusing fields which had been done by Kossel and Rutemann in Danzig prior to World War II. Artsimovich discussed the possibility of increasing dispersion by use of strong focusing fields. [redacted] Artsimovich was confusing dispersion and resolving power, and that several hundred milliamperes ion current had been achieved with a low-voltage-arc ion source charged with uranium-bromide. [redacted] this work was completed by 1951. In 1952, an electromagnetic separator was delivered to Sinop, where separation of calcium, zinc, and germanium was performed. Although [redacted] the Soviets built several instruments for electromagnetic separation of uranium isotopes, [redacted] a large-scale separation plant using this principle was never built. [redacted] no evidence, however, to support this contention. 25X1
126. Artsimovich did not visit Agudzeri in connection with the hot-anode ion-source development, although [redacted] this ion source was developed for Artsimovich's laboratory, since it was generally understood by the German specialists that Artsimovich's laboratory was responsible for the development of the electromagnetic isotope-separation method. Fritz Bernhardt of Sinop upon returning from one of his many official business trips to Leningrad [redacted] that Artsimovich was director of an institute in that city, in which electromagnetic isotope separation of uranium was performed. 25X1

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127. Sometime around 1953, [redacted] Artsimovich was honored with a Stalin Prize. Finally, [redacted] the change in Artsimovich's interests might be explained on the following basis: By 1952, Artsimovich had successfully solved the electromagnetic problem on uranium, and by 1953 he was separating lithium isotopes with his electromagnetic separators. It must be noted, however, that Artsimovich's visit in 1953 was again of the pre-1952 type, namely, the Soviets listened while the Germans reported. Except for a few sparse questions, Artsimovich was careful not to reveal anything about his own work. 25X1

#### HIGHLIGHTS FOR THE YEAR 1954

##### Commission from Kharkov

128. Towards the end of 1953, or possibly in 1954, a number of Soviets arrived from an unidentified institute in Kharkov. They asked for help in the design of an ion source to be used for polarized hydrogen atoms. [redacted] The calculations for such an ion source were performed by Bernhardt in Sinop, and in early spring 1955 the completed ion source was sent to Kharkov. No further details were known [redacted] 25X1

##### Ion-Source Colloquium

129. During July 1954, the last colloquium was held in Sinop, which was again attended by a large number of Soviets coming from outside Sukhumi. [redacted] at this meeting von Ardenne was attacked by a member of the Academy of Sciences, who allegedly referred to him as "a mechanic but not a scientist." The colloquium dealt with ion-source problems on aspects of which von Ardenne and Demirkhanov had worked. Only the significance of ion sources in isotope separation and other atomic transformations was discussed, not mass-spectrometer sources. 25X1

##### Mass Spectrometer from NII-160

130. During 1952, Zavenyagin had promised [redacted] a mass spectrometer that had been manufactured at NII-160. In December 1954 this mass spectrometer finally arrived. The delay [redacted] was caused by the very heavy demand for these machines until that time. Thereafter, the supply seems to have exceeded the demand, as there were not enough Soviets qualified to operate the machines. As an example, [redacted] even Tbilisi University had a mass spectrometer but no one qualified to operate it. The mass spectrometer which arrived was essentially a copy of source's model. It was equipped with the three ion sources listed in paragraph 111. 25X1

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AWARDS TO ATOMIC SCIENTISTS

131. At the time that the assignment for the mass spectrometer was given during fall 1945, Gen. Zavenyagin pointed out that, upon the completion of the first phase of the program, prizes and premiums would be given to those who had successfully completed a project. Sometime later, a list of such projects and respective gratuities was shown by Gen. Kochlavashvili to the Germans in Agudzeri. [redacted] similar offers might have been made to the leading Germans who attended the Beriya conference in August 1945. 25X1 25X1 25X1
132. Riehl completed his project by the end of 1946 and [redacted] been shown, [redacted] first mass spectrometer was successfully tested during fall 1947. It was, however, not until two years later, in fall 1949, that the first awards were issued to the Germans; of course, cash premiums were given earlier. [redacted] in 1947 von Ardenne received a cash premium of 50,000 rubles, as did Hertz and his Soviet assistant Gverdtsiteli. The fact that there was a delay of two years implies [redacted] that the first phase of the atomic program in the USSR was not completed before fall 1949. 25X1 25X1 25X1
133. [redacted] listing of Soviets and Germans who had been honored with awards. Accordingly, the following employees of the Ninth Directorate were issued prizes during October 1949:

Nikolaus Riehl	:Stalin Prize First Class Order of Lenin Hero of Labor
Guenther Wirths <sup>24</sup> and Herbert Thieme	:Collective prize with a number of unidentified Soviets; Stalin Prize Second Class; and each received the Order of the Red Banner
Schuetze (source)	:Stalin Prize Second Class Order of Lenin
Chekhovtsov ) Ordzhonikidze source's Bolotnikov ) assistants Chernov. )	:Order of the Red Banner <sup>o</sup> :Order of the Red Banner :Honor Medal :Honor Medal
Director of Elektrostal	:Hero of Labor Order of Lenin
Chief Engineer of Elektrostal	:Hero of Labor Order of Lenin.

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Zavenyagin : Order of Lenin  
Hero of Labor

Zverev : Order of Lenin

Leypunskiy : Order of Lenin

According to statements by Gen. Zverev, 20 to 30 additional Stalin Prizes were distributed to Soviets for work on atomic research at this time, but the Ninth Directorate had won the majority of the honors.

134. [redacted] recipients of medals and awards  
irrespective of date or employment affiliation. The following is a  
list of all additional award winners [redacted]

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Chekhovtsov : Stalin Prize Third  
Class during 1953/1954

Yemelyanov : Hero of Labor probably  
in 1954; as of 1955 he  
had never been awarded a  
Stalin Prize.

Hertz : Collective Stalin Prize  
Barwich Second Class during  
Krutkov 1951/1952 and Order of  
the Red Banner to each.

Peter Adolf Thiessen : Collective Stalin Prize  
Ludwig Gustav Ziehl First Class during 1951/  
Burdiasvili 1952.

Yermin : Collective Stalin Prize  
Yermina First Class during 1951/  
Reichmann (posthumously) 1952 and Order of Red  
Banner to each. Reichmann  
was also awarded the Order  
of Lenin.

Manfred von Ardenne : Collective Stalin Prize  
Heinz Ernst Froehlich 25 Second Class during 1953.  
Demirkhanov and two  
other Soviet assistants

Artsimovich : Hero of Labor sometime  
after 1950.

Kurchatov : Hero of Labor sometime  
after 1950.

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Migulin

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in 1950 had one  
Stalin Prize First Class.  
Was awarded Stalin Prize  
Second Class in 1953.

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Isayev

in 1948, he had  
two Stalin Prizes, a second  
and a third class.

Herbert Thieme and five  
Soviet assistants

: Collective Stalin Prize  
Second Class during 1950.

Novikov

: Stalin Prize Second Class  
during 1950.

Blokhintsev

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(1946) had Stalin Prize  
First Class.

Alikhanov

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(1953), had four Stalin  
Prizes of which one was for  
his varitron experiments.

Kikoin

: Probably received Stalin  
Prize and Hero of Labor  
award but not  
certain.

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Flerov

: Had Stalin Prize First  
Class for natural-fission  
experiments

25X1

Smorodinskiy

: Had Stalin Prize First  
Class  
in 1950s.

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MISCELLANEOUS INTELLIGENCE

Chelyabinsk [N 55-10, E 61-24]

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When once discussing another German atomic group with [Maks Leontovich]  
Kosyrev from the Ninth Directorate's Personnel Section in charge of  
German affairs, the latter said: "He is in Chelyabinsk. Oh no, excuse

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me, that is another group." It was clearly a slip of the tongue, and the Soviet was visibly embarrassed. [redacted] this town had some connection with the Soviet atomic project, but [redacted] would venture no further guess.

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Elektrosila

[redacted] there were two factories by the name of Elektrosila one in Leningrad and one in Moscow. The Moscow factory of Elektrosila supplied three or four magnets for source's experimental mass spectrometer (MS-O) in 1946 or 1947. The magnets, supplied however, could not be used in his mass spectrometer. [redacted]

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[redacted] difficulties had been encountered in connection with magnets and that drawings and specifications for these magnets had been sent to the Ninth Directorate. After many promptings, instructions came from the Ninth Directorate to call the Moscow factory directly by the high-frequency telephone in Agudzeri. This was the only time that Elektrosila at Moscow was mentioned. The Leningrad Elektrosila factory was made known [redacted] by [Fritz] Bernhardt, who frequently traveled to this factory which allegedly worked on ion sources for electromagnetic separators. In 1947 or 1948, Bernhardt spent a number of months in that factory in Leningrad.

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Krasnyy Proletariy

A factory in Moscow which supplied a number of lathes and other tool machines for Agudzeri. These were exact copies of German machines and the parts were interchangeable.

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Sokol, Moscow

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Laboratory 9 headed by Chevchenko was located near-by.

Ulitsa Kirova

At Ulitsa Kirova (probably No. 29) in Moscow is located a transient hotel of the Ninth Directorate and/or First Chief Directorate, at which low- and medium-ranking Soviets reporting to these offices stayed. After the guest house in Ozery was given up by the Ninth Directorate and used by Vannikov in 1950/1951, the Germans from Sukhumi also stopped at this hotel.

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ASSIGNMENT OF MASS SPECTROMETER

136. The assignment for the construction of a mass spectrometer was the outgrowth of discussions held in the Agudzeri in August or September 1945, which were attended among others by Hertz, Zavenyagin, Kikoin, Flerov, Bonch-Bruyevich and Kalishnikov.

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REFERENCE MATERIALS

137. Before December 1946, there was no available reference material. After that date a Soviet translation by Bonch-Bruyevich of an article by A.O. Nier dealing with a comparison of two ion sources by means of a compensation method became available.

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BASIC CONSIDERATIONS

139. Because of the high chemical activity of fluorine and the instability of  $UF_6$ , it was evident to source from the very beginning, that the production of a sufficiently constant ion beam would be a major difficulty, and that this alone would be the factor that would limit the accuracy of measurements. As a result of this consideration, [redacted] began the construction of two types of ion sources and of experimental apparatus which would permit the measurement of their yield and energy spectrum. The first ion source was of the Heil type which had been described in Zeitschrift fuer Physik, 120., 212., 1943. The other ion source was of the Nier type described in Physical Review, 52. 933. 1937(?). Rough schematic diagrams of these sources are presented in Figures 1 and 2 [see page 55]. In neither case is the auxiliary magnetic field which was used for electron focusing shown. 25X1
140. The design structure was made, from the very beginning, as mechanically rigid as possible, in order to test the stability of the ion beams and the durability of the ion source when used with fluorides such as  $WF_6$  and  $UF_6$ . For this purpose, a design was selected which, as far as possible, avoided the use of glass, as fluorides are very destructive to glass. The gaskets used as a seal between two steel flanges were made of copper rings. These proved to be most satisfactory and could be heated to temperatures as high as  $600^\circ C$ .
141. The circuits for measuring the ion current of the two types of sources are depicted in Figures 3 and 4 [see pages 56 and 57]. The arrangement for the retarding potential measurements is shown in Figure 5 [see page 58]. A comparative test of the two ion sources was made with each ion source at approximately  $10^{-4}$  mm of mercury and with  $N_2$  in the ionization chamber. The measurements were made with a McLeod manometer. The results were as follows:  
[Text continues on page 59]

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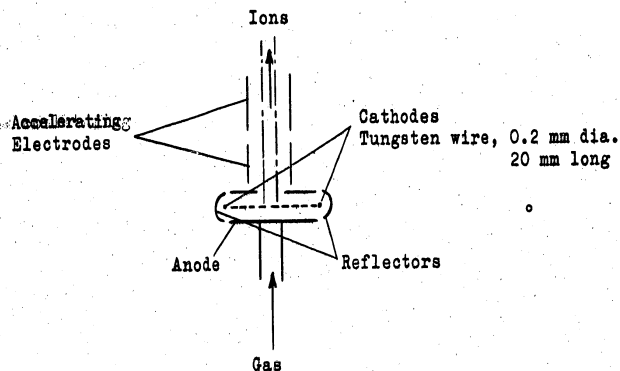


Figure 1: Heil-Type Ion Source

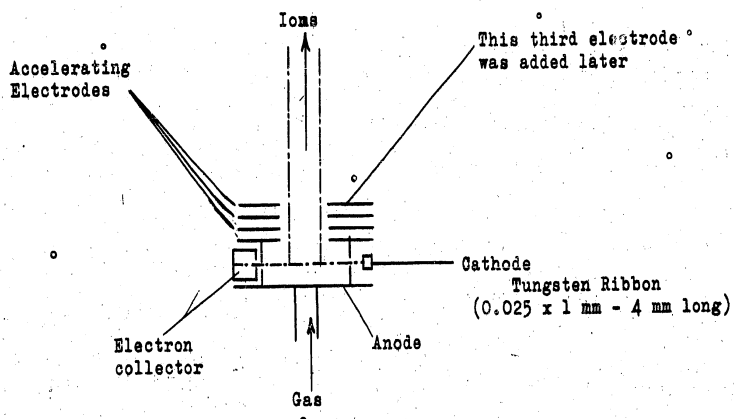


Figure 2: Nier-Type Ion Source

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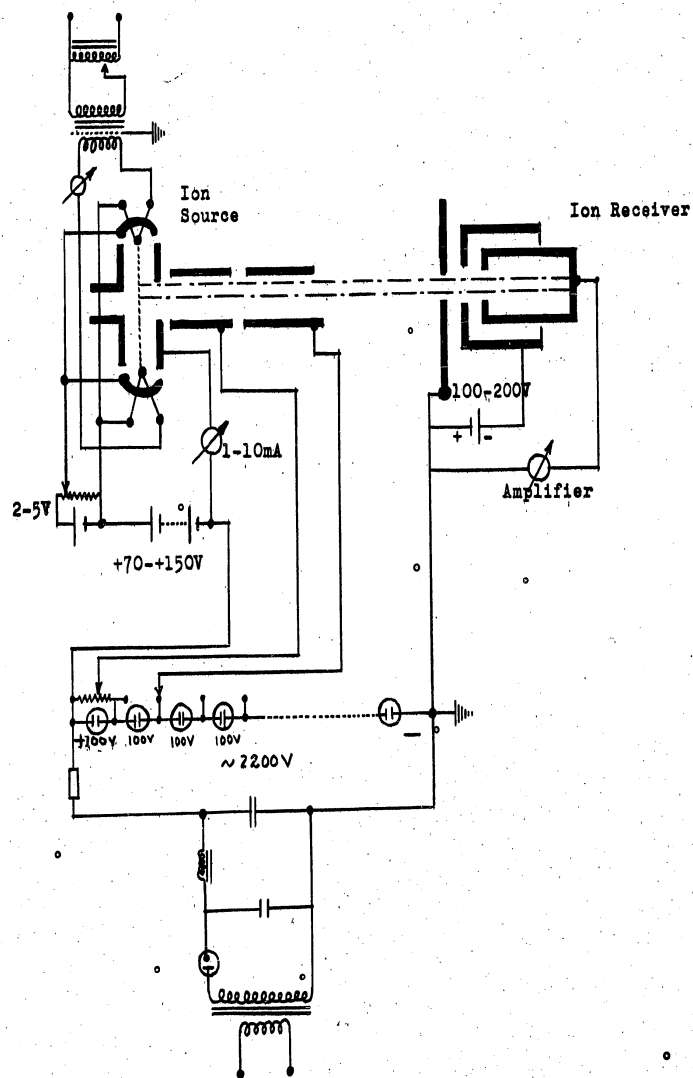


Figure 3; Circuit Used With Hail-Type Ion Source

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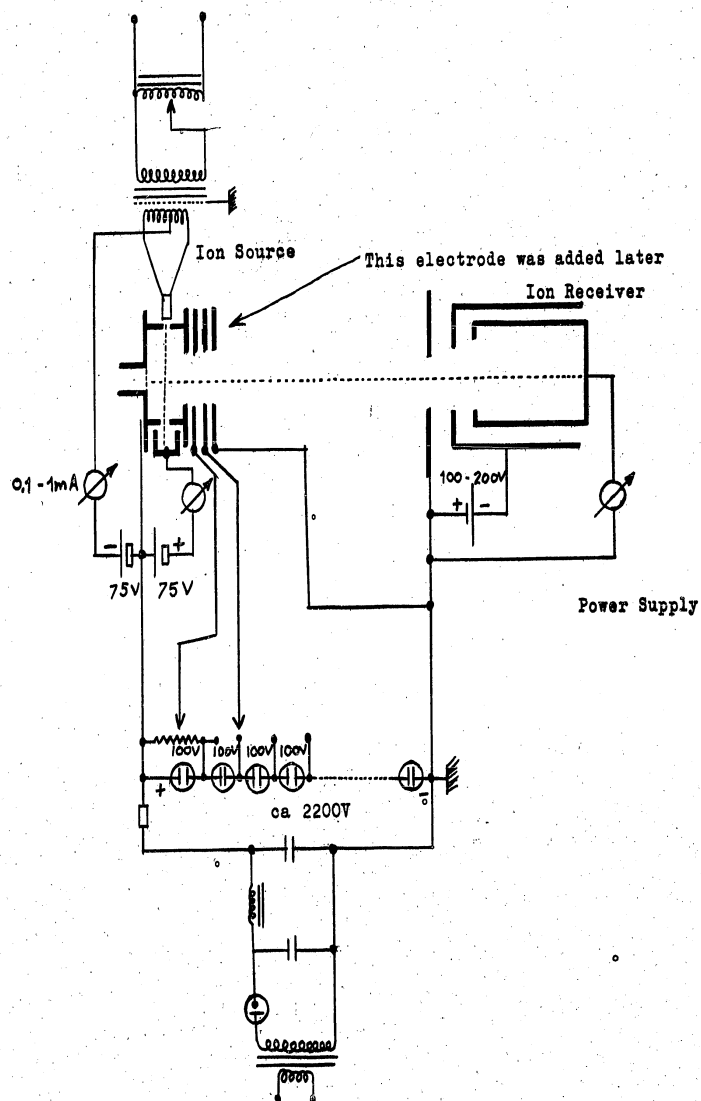


Figure 4; Circuit Used With Nier-Type Ion Source

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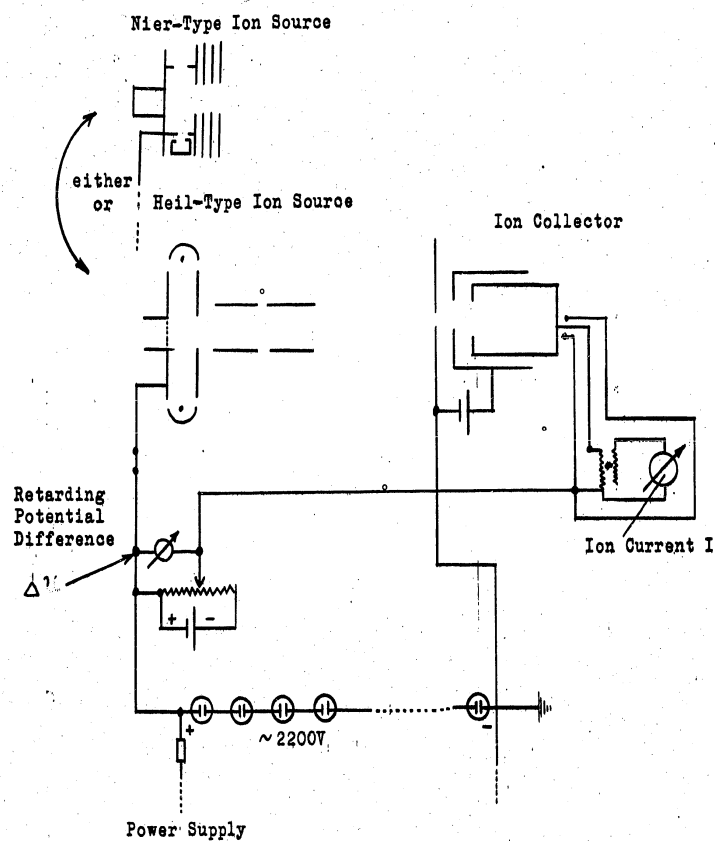


Figure 5; Circuit Used For Measurement Of Retarding Potential

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Heil Ion Source

Electron current: approximately 5 mA

Electron energy : approximately 150 eV

Positive ion current  $i_+ \sim 10^{-5}$  amperesNier Ion Source

Electron current: approximately 0.5 mV

Electron energy : approximately 75 eV

Positive ion current,  $i_+ \sim 10^{-7}$  amperes

The currents were held stable at  $\pm 1$  percent for a number of hours when, among other things, the diffusion-pump heating was kept stable. Pump heating constancy, unexpectedly, gave rise to great difficulties. Note-worthy, in these tests, was the following:

Heil Ion Source

- a. The ion current was found to be not proportional to the gas pressure but rather to evident saturation in the acceleration field. This was probably the result of space-charge effects.
- b. The ion current depended in a complex manner on the electron energy and the magnetic field used to guide the electrons.
- c. As a result of the relatively high ion current, a strong extraction field was required which led to:
  1. broad energy distribution of the ion beam, and
  2. energy distribution dependent on current strength.

Nier Ion Source

- a. The ion currents continued to be proportional to the gas pressure.
- b. The currents followed to some extent the course of the ionization function for He, Ne, and Ar. This was less pronounced for  $H_2$ ,  $N_2$ ,  $O_2$ , and  $CO_2$ .
- c. Energy distribution was dependent on the type of gas but not on the current intensity.

Graphic Comparison

In Figure 6 [see page 60] the current voltage characteristics for the respective ion sources are depicted. The energy distribution results obtained in the tests of the two ion sources are shown in Figures 7 and 8 [see page 61].

[Text continues on page 62]

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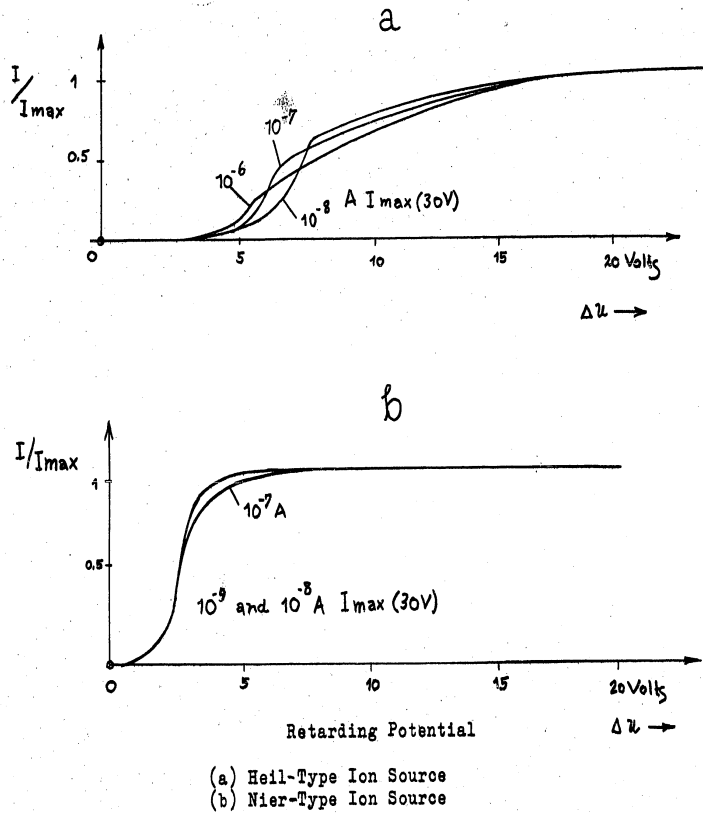
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Figure 6; Current-Voltage Characteristic Curves

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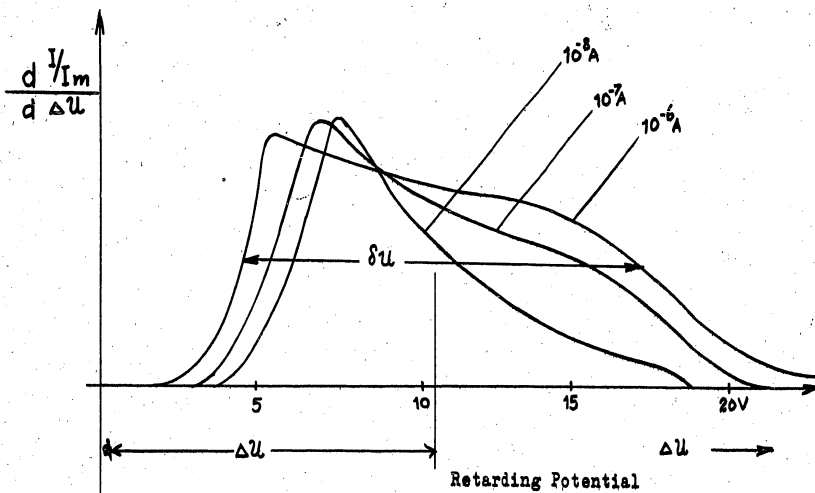
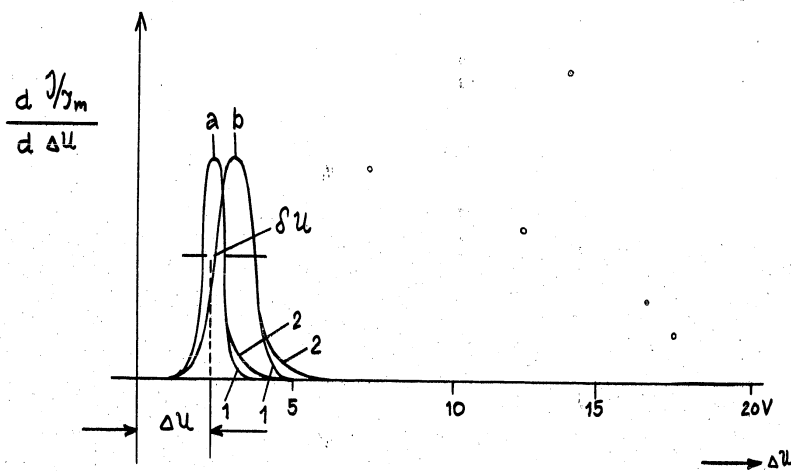


Figure 7: Heil-Type Ion Source Derivative Of Current-Voltage Characteristic Curve.



(a) He<sup>+</sup>, Ne<sup>+</sup>, Hg<sup>+</sup>

(b) CO<sub>2</sub><sup>+</sup>, CO<sup>+</sup>, C<sup>+</sup>, O<sup>+</sup> (the peak for UF<sub>6</sub> is somewhat broader, for N<sub>2</sub><sup>+</sup> and O<sub>2</sub><sup>+</sup> somewhat narrower).

(1) for I ≤ 10<sup>-8</sup> amp.

(2) for I about 10<sup>-7</sup> amp.

Figure 8: Nier-Type Ion Source Derivative Of Current-Voltage Characteristic Curve

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It is evident that:

for Heil type  $\Delta u$  (retarding potential) 8 to 12 volts

$\delta u$  (breadth of peak) 6 to 14 volts

for Nier type  $\Delta u$  (retarding potential)  $\sim 1.6$  (atom gas) to 2.1 volts  
(molecular gas)

$\rho u$  (breadth of peak)  $\sim 0.7$  to 1.2 volts

142. The two ion sources revealed exactly the same behavior in tests with  $UF_6$  and with  $WF_6$ . At first, the ion currents were ( $10^{-5}$  A for Heil and  $10^{-7}$  A for Nier) and stable in the usual manner. No unusual behavior was noted in the first half hour of operation. In both cases, when using  $UF_6$ , the emission from heated filaments increased slowly, so that it became necessary continually to lower the heating current in order to maintain a constant emission current. It was evident that the filament became covered with a uranium layer which, similar to the behavior of a thorium layer, reduced the work function of the surface. After approximately one hour with the Heil ion source, or after approximately two hours with the Nier ion source, the ion current became inconstant and electric shorts occurred between the lens electrodes or to ground. These prevented further observations. Disassembly revealed that the surface of the porcelain supporting rods had become conductors and, further, had been markedly attacked by fluorine. Substituting quartz, Pythagora Masse, [Pythagora Masse is a commercial term for a high melting porcelain type mass produced by the plant, Haldenwanger in Berlin; in Germany, it is generally used as a fireproof and corrosion-proof ceramic mass], or Calite in the apparatus led to more or less the same results. The use of sintered corundum ( $Al_2O_3$ ) however, was found to remove the interfering short circuits completely, even if the ion source was not heated first or if the  $UF_6$  was not pure.
143. After a longer operation with  $UF_6$ , the ion currents slowly began to lose their constancy, and their intensity fluctuated around 10 percent. The reason for this was that the interior of the anode box was covered with thin layers of  $UF_4$  which were good insulators, in a vacuum and as long as it was dry, which charged up and permitted the electrons and ions to oscillate back and forth. This effect was especially pronounced in the Heil ion source because of its higher anode temperature.
144. Nevertheless, using the 10 times smaller ion currents, i.e.,  $10^{-6}$  A for the Heil ion source and  $10^{-8}$  for the Nier ion source it was possible to obtain fairly stable ion currents which lasted over a number of hours. It appeared promising, therefore, to continue the development of both types of ion source, coupling them with different analyzers. In this connection it was an especially interesting requirement that the measurements of the two ion currents to be compared could be made simultaneously or very rapidly in succession. In view of the broad energy distribution, a double focusing was required for the Heil ion source, while a single angle focusing was sufficient for the Nier ion source.

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145. [redacted] decided at the time to build first a mass spectrometer with double focusing. The sole reason for this decision was the desire to introduce some innovations. Besides, the Soviets were not able to supply [redacted] electrometer tubes, so that measurements with the approximately 100 times greater ion currents of the Heil source, which permitted the use of ordinary tubes, seemed to be the simpler solution. On the other hand, however, it was evident from the start that absolute measurements of ion-current relationships in the Heil ion source would not be possible because of the interference of space charge. Consequently, suitable calibration instruments would be required.
146. The arrangement of fields selected is shown in Figure 9 [see page 64]. It is evident that this arrangement was very similar to the old system of Bainbridge and Jordan reported in the Physical Review 50. 282., 1936. A deflection angle of  $120^\circ$  was selected for the electric field, in which the ion and outlet slits were somewhat separated from the electric field. This meant that the dimensions of stray-field diaphragms for the deflection condenser had to be calculated according to Herzog's proposal in Zeitschrift fuer Physik 97. 596., 1935, and the Monatsschrift fuer Elektrotechnik 29. 790., 1935, and to be incorporated in the device so that the actual deflection and lens effect of the condenser was equal to the ideal. Another advantage was that the edges of the inlet slits and the energy aperture diaphragm near the outlet of the condenser were in the field-free space. This was also desirable because it diminished errors resulting from charging.
147. The increase in length of the beam path amounted to only about 1.3 percent and thus was not an important factor. The angle of aperture  $\alpha$  of the inner rays as determined by the slit-system  $S_0$  and  $S_1$  was

$$\alpha = S_1 \left( \frac{S_0}{S_1} + 1 \right) / 2d$$

The width of the slit  $S_2$  was selected so that the entire velocity spectrum could pass through it without interference. With an acceleration voltage of  $U = 2,500$  v, there was obtained  $\beta = 4\%$ , maximum  $5 \cdot 10^{-3}$ . The line spread resulting from energy focusing errors was of the order of  $V_e \cdot \beta \leq 5 \cdot 10^{-3}$  mm and could therefore be neglected at slit widths ( $S_1$  and  $S_2$ ) of approximately 0.1 and 0.5 mm respectively. For the resolving power, one may write the simplified expression:

$$A = \frac{M}{\Delta M} = \frac{1}{\frac{S_1 + S_2}{V_m} + \frac{1}{3} \alpha^2}$$

[Text continues on page 65]

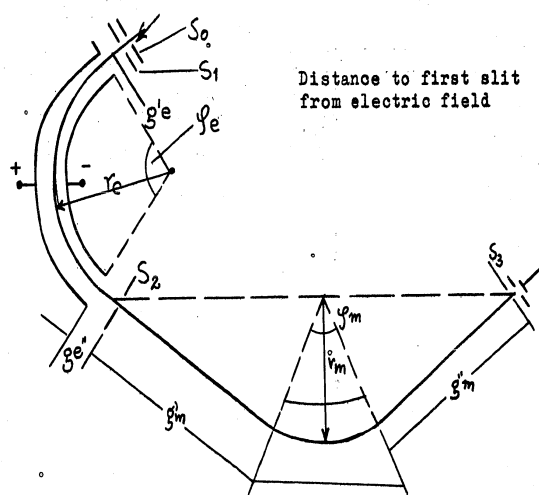
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$$r_e = r_m = 150 \text{ mm}$$

$$\phi_e = 120^\circ$$

$$\phi_m = 60^\circ$$

$$g_e = g'_e = 13.6 \text{ mm}$$

$$g_m = g'_m = 259.8 \text{ mm}$$

Figure 9; Ion Optical System Used In Mass Spectroscope  
(Bainbridge - Jordan Type)

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The angle of aberration-error of the electrostatic  $\sim \frac{4}{3} \alpha^2 \cdot V_e$  and of the magnetic field  $\alpha^2 \cdot V_m$  nearly compensated one another at  $V_e = V_m$  to  $\sim \frac{4}{3} \alpha^2 V$ . In order to measure better the maximum of the outlet ion beams, the width of slit  $S_3$  was selected which was at least equal to twice  $S_1$ . The lateral enlargement equaled one for this case. When:  $S_0 = 0.3$  mm;  $S_1 = 0.1$  mm;  $S_2 = 0.2$  mm then there was obtained:

$$\alpha = 2 \cdot 10^{-2} \text{ and } A = 470.$$

That is, the resolving power was sufficient for measuring uranium isotopes at  $M = 330$ . At the same time the relative opening was sufficiently wide so that a great intensity of illumination was obtained.

#### MEASURING ION SOURCES

148. In the light of the above findings, it was therefore considered likely that a very simple measuring device would suffice for the ion currents. The following process was used for measurement: The acceleration voltage was modulated with a saw-tooth voltage of approximately 50 ops. The deflection voltage near the energy filter was varied in the same way. This was accomplished simultaneously by means of a common voltage divider. Thus, a part of the mass spectrum would be periodically led past the slit  $S_3$ . For each mass line, there were recorded at the collector short current impulses, which were amplified by means of an AC amplifier. A cathode-ray oscillograph, fed with the same deflection voltage, was used to make the lines visible as a standing picture which could then be photographed and measured.
149. The process as related thus far would put great demands on the linearity and time response of the amplifier and would not permit a very accurate measurement of extreme intensity relationships. This problem, however, was resolved by making the input resistor of the amplifier reducible by means of a synchro switch. Thus, the stronger ion current would pass only through a measurable part of the input resistor, and the amplifier would respond with a current surge equal to that produced by the weaker ion currents.
150. It would then no longer depend on the linearity of the amplifier and furthermore, the adjustable resistor relationship would permit the measurement of greater intensity differences with as much accuracy as two mass lines of equal intensity. At 100-mm impulse-height on the oscillograph tube (if the noise level were not too great), it would still be possible to read  $\pm 1$  mm. Thus, in principle, it was possible to obtain an accuracy of one percent, and, in fact, such was the case in measurements made with isotopes of the lighter elements such as  $Cl^{35}$ ,  $Cl^{37}$ , and  $Cl^{39}$ .

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151. The principle disadvantage of this process was that it was not suitable for absolute measurements. During the measuring operation, the acceleration voltage of the ions did not remain constant but instead varied in order to send ions of different masses by the same route through the magnetic analyzer field. In this process, the ion output of the ion source would change somewhat, and consequently differed a bit from line to line.
152. The "voltage effect", is well known in mass spectroscopy, and its influence on the measuring result is compensated for in exact measurements by varying not the acceleration voltage but rather the magnetic field when adjusting for the various mass lines. This, however, cannot be done in this process because of the inertia of the magnetic field. Nevertheless, good criteria for the magnitude of the voltage effect can be obtained, if the line on the oscillograph tube is shifted with the aid of a magnetic field variation. If the height of the line does not change, no voltage effect is present. Such a condition can easily be obtained by altering the voltage along the first acceleration electrode and by adjusting the magnetic field of the electron guide. Once the adjustment has been made, the voltage effect will be smaller than one percent and will be constant in respect to time over a large range of masses.
153. The measuring speed of such an arrangement is extremely great when compared with other mass spectrometers. Consequently, fast-changing processes can easily be observed and captured by photographing the projection on the screen. It was possible, for example, to follow with ease the start-up of a Ne isotope-separation process in a cascade consisting of 20 Hertz-type countercurrent-diffusion pumps. The arrangement is depicted in Figure 10 [see page 67]. The gas in the final stage circulated through a needle valve from which a small amount was removed from the stream of gas in order to feed the ion source. The projection screen was photographed every 15 seconds with a miniature camera, and upon development of the film the lines were measured with a comparator.
154. The recordings at 15 second intervals after "start-up" on the "heavy end" and the "light end" are depicted in Figure 11 [see page 68]. In this manner it was possible to clarify in a short time many questions dealing with the stable operation of cascades, with or without extraction. Optimal requirements could be experimentally derived which were unobtainable from theoretical analysis. By and large, this mass spectrometer worked well with elements up to mercury, but source admitted that the measuring accuracy for rare isotopes was relatively low because of the high noise level in the apparatus.
155. Experiments with  $UF_6$  were at first also rather promising. All ions of the series  $U^+$  to  $UF_6^+$  were examined. It was observed that the ions  $UF_5^+$  had a relatively high intensity, sometimes as high as the ion  $UF_6^+$ , and that many  $F_2^+$  ions were encountered. This permitted the inference that the temperature in the ion source was too high, and that a thermal decomposition of  $UF_6$  occurred according to the equation:  $UF_6 \rightarrow UF_4 + F_2$ .
- [Text continues on page 69]

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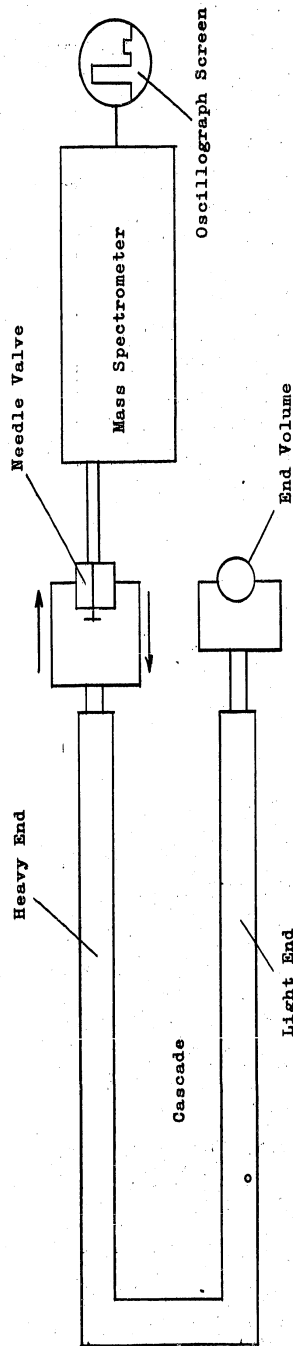
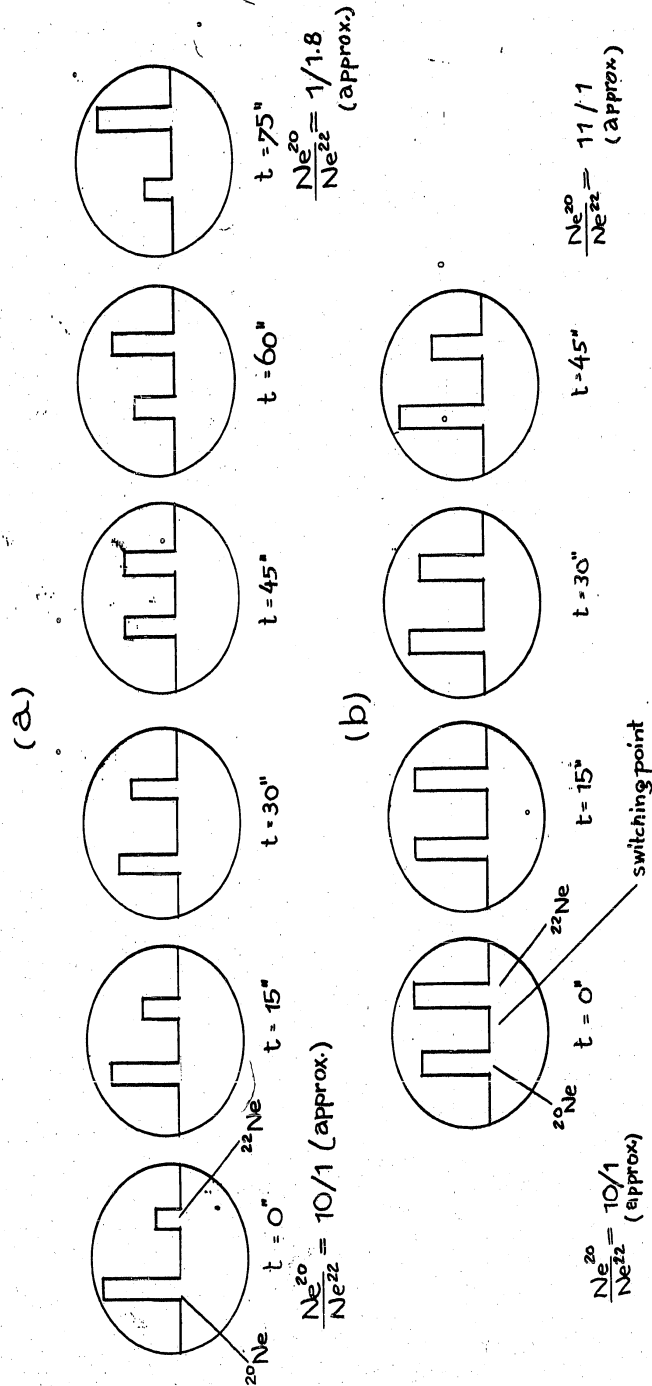


Figure 10; Experimental Arrangement For Study Of Countercurrent Diffusion Cascade

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(a) Mass Spectrometer connected to heavy end. (b) Mass Spectrometer connected to light end.  
Figure 11; Approach To Equilibrium Of A Countercurrent Diffusion Cascade

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156. In the process of ionization of  $UF_4$ , the most abundant ion found was  $UF_3^+$ . In addition, there appeared ions which stemmed from tungsten fluorides. This indicated that a reaction between the  $UF_6$  and the hot tungsten cathode also took place. The ion currents were not exceptionally large, but they were quite stable and it was possible to observe a  $^{235}UF_5^+$  line, though at this point a measurement with one percent accuracy was still out of the question.
157. After these tests, the mass spectrometer was switched off and heated in order to remove the fluorine compounds. The following day the mass spectrometer was disassembled, and the width of the slits ( $S_1$  and  $S_2$ ) was reduced in order to make possible a resolving power of approximately 400. After evacuating (pumping) and heating, it was found that the porcelain insulators, on which the ion source parts had been mounted, no longer insulated satisfactorily and thus permitted a leakage current, which made further work with the mass spectrometer absolutely impossible. Not even the resolving power for  $Hg^+$  could be controlled. The replacement of the old porcelain rods with new ones removed this trouble but only for a short time during which measurements of  $^{235}UF_5^+$  could be made with an accuracy of  $\pm 10$  percent. Greater accuracy could not be obtained as the noise was too great at smaller intensities. Figure 12 [see page 70] is a sketch of the appearance of the peaks on the oscillograph screen. 25X1
158. If the intensity was increased, which could be done, by increasing the gas pressure or increasing the electron emission and the auxiliary magnetic field in the ion source, increasing the number of oscillations of the electrons, then there would occur an immediate spreading-out of the peaks. For this reason, abundance measurements were not possible.
159. In neither case was it possible to detect the slightest trace of  $^{234}UF_5^+$ . It was believed that the space-charge effects could have been eliminated, if it had been possible to raise the acceleration voltage from approximately 25 to 30 kv. The mass spectrometer, however, was not equipped for this, and therefore this possibility could not be explored.
160. The other way, that is, to use a secondary-emission amplifier for amplification of ion currents, was meanwhile pursued upon source's and Kvartskhava's and Poroshin's suggestion. Source had approximately 25 to 30 grams of pure Be available, from which small quantities of copper-beryllium and nickel-beryllium were prepared. Kvartskhava, however, was not successful in shaping the layers in a manner that would be stable when exposed to air. As source could not obtain any additional Be, these experiments had to be discontinued by his section. Source was not aware, at that time, of the possibilities offered by silver-magnesium for this application.

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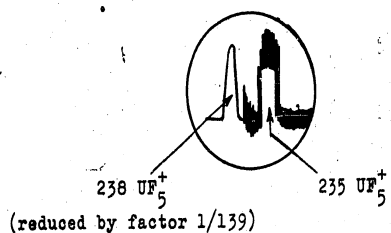


Figure 12; Appearance Of Normal Uranium Fluoride Ion Peaks On Screen Of Mass Spectroscope

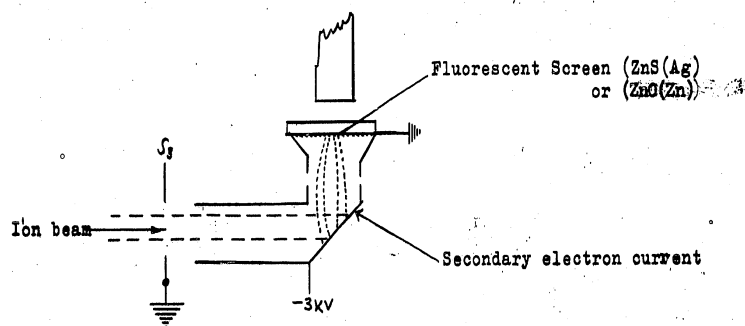


Figure 13; Arrangement Of Secondary-Emission Ion Detector

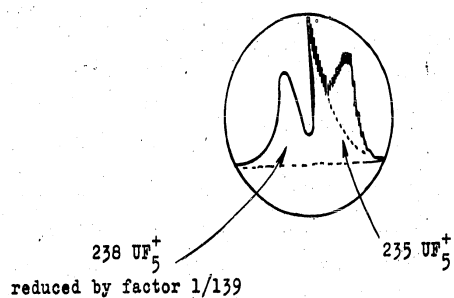


Figure 14; Appearance Of Normal Uranium-Fluoride Ion Peaks With Use Of Secondary-Emission Detector.

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161. Shortly afterwards, photo-multipliers were received [redacted] from a Moscow insititue. These had a rated sensitivity of  $\sim 1 \text{ A/Lumen}$  at a dark current of  $\sim 10^{-9} \text{ A}$ . They were Springbogen multipliers with an Ag-AgO-Cs<sub>2</sub>O-Cs cathode and similar deflectors. The photo-multipliers were used in the following manner: The ion beam, after passing through the slit  $s_3$ , received a supplementary acceleration of about 3 kv and then was reflected onto a common and unsheathed Ni electrode. The secondary electrons that were released were then laterally drawn out of the electrode and accelerated to about 3 keV, whereupon they struck a fluorescent screen, as shown in Figure 13, [see page 70].

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162. In this process, there occurred a multiplication of the current by a factor of two to three, which was not important from a standpoint of multiplication. The light produced by the phosphorous was then reflected onto the photo-cathode of the multiplier by means of a small silver-plated mirror. The observed result was that, at a suitable temperature for the multiplier,  $\sim 60^\circ \text{ C}$ , the noise level was markedly reduced. Figure 14 [see page 70] is a picture of the appearance of normal uranium-fluoride ion peaks.

163. It was possible to make the  $^{234}\text{UF}_5^+$  line visible, although it was not measureable, as it was almost completely masked by noise. The relationship of the two U-line currents was strongly dependent, however, on the current, which indicated that the strong  $^{238}\text{UF}_5^+$  currents produced saturation of the multiplier. From this condition also resulted the different line forms. When the total intensity was reduced, the relative contribution of the noise increased markedly, and this again made abundance measurement impossible. [See Figure 15, page 72].

164. These findings led to a discontinuation of this particular version of the mass spectrometer. The Ninth Directorate in Moscow was notified that measurement of U-isotopes without utilization of electron-meter tubes and high-ohm resistors, of at least  $10^{10} \Omega$  to  $10^{12} \Omega$ , would not be possible, and that steps would have to be taken to develop electron-meter tubes and resistors. The immediate response from Moscow was a series of recriminations.

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[redacted] Within a few hours, however, the Ninth Directorate completely reversed its position. [redacted] suddenly promised that electron-meter tubes and high-ohm resistors would be purchased outside the USSR, and the mercury diffusion pumps [redacted] would be placed at [redacted] disposal. It was also pointed out, however, that they could not give a definite delivery date.

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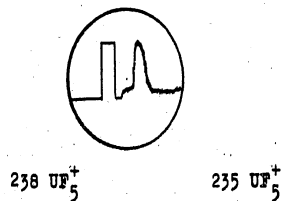


Figure 15; Appearance Of Normal Uranium-Fluoride Ion Peaks

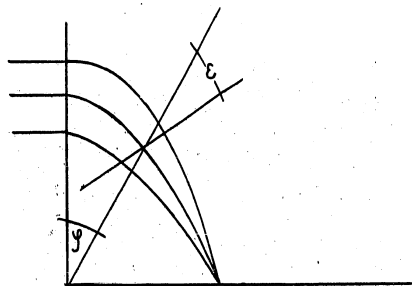


Figure 16; Focusing of Ion Beam by a Straight-Line Limited-Sector Field of Angle  $Q$

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165. It was under these circumstances that the second mass-spectrometer development was begun. The first development had given [redacted] 25X1 experience and some fruitful insights which guided him in the design of the mass spectrometer. Some of these are listed:

- a. In order to obtain a relatively good working life for the ion source, the  $UF_6$  must be as pure as possible. Above all, it must be free of oxygen compounds and all traces of air. Otherwise, oxidation will take place along the walls of the ion source's anode. As these compounds constitute insulating layers they may charge up and thus lead to variations in the electron current.
- b. The pressure of the  $UF_6$  in the ion source must be as small as possible, since even the purest  $UF_6$  will produce some degree of corrosion, especially in those places which are hit by ions and on which adsorbed  $UF_6$  will decompose. The greenish-yellow color of the deposit identified the contamination as  $UF_4$ . These effects, which also occur near the inlet slit of the mass spectrometer, often cause a transverse oscillation of the ions in the beam and thus impair the reproduction image.
- c. It is necessary to prevent the  $UF_6$  from entering the analyzer tube, because other ions than those just measured must strike the walls. Should an insulating deposit be formed, then charge-ups will occur which lead to a projection image which is out of focus. It is for this reason that a separate mercury diffusion pump and cooling traps were provided for both the ion source and the analyzer.
- d. In order to achieve a good vacuum, it is not merely necessary that the ion source and the analyzer be carefully baked-out prior to putting the  $UF_6$  into the instrument. In addition, they must be heated afterwards in order to remove all the adsorbed  $UF_6$ . If the adsorbed  $UF_6$  is not removed prior to interruptions in operation, it will react with gaseous traces that have entered the instrument and will form troublesome insulating layers.
- e. In view of the fact that it is not possible to produce stable ion currents sufficient to permit measurements of one percent accuracy for longer periods, it is necessary that measurements of isotope concentration be performed by the simultaneous measurement of the two ion currents. Since in tests of enriched material,  $^{234}UF_5^+$  is often found to occur with an abundance in excess of one percent of  $^{235}UF_5^+$ , it is necessary that the resolving power be great enough so that both are clearly separate. Furthermore, the collector must be designed in such a fashion that  $^{234}UF_5^+$  and  $^{235}UF_5^+$  can be separately measured.

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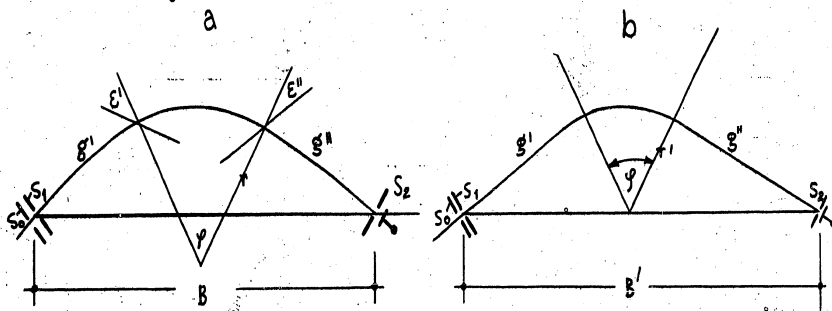
166. It is, of course, possible to avoid these difficulties by frequent cleansing of the ion source and the slit-system ( $s_0$  and  $s_1$ ). This, however, will cause the operation time that is available for measurements to be much too small. The error which is most troublesome for the measurements is the minute lateral displacement of the ion beam. In part this deflection is periodic. This can be seen from the fact that the oscillograph image jumps back and forth, sometimes as much as one-half a mass unit at a mass of 330.
167. Sometimes the image will be displaced laterally for a period of time, anywhere from a few seconds to one minute, and then will suddenly jump back to its original zero position. After the slit system has been cleaned, this effect will disappear completely for some time but suddenly after a few hours will begin anew in this or another form.
168. To reduce this effect, it ought to be possible to employ an image-error correction projection. In such a projection, a spread of the picture for larger aperture ranges is impossible. The possibility of employing such image-error correcting projections was known to source. While in Agudzeri, he gave lectures once a week to his assistants, and among these were some lectures dealing with the problem of projections using magnetic sector fields of different shapes. During these lectures, and as exercises, the dispersion, the resolving power, and the image error were calculated. It was on one such occasion an image-error correction of the second order caused by what is now known as "inflection field" arrangement. 25X1
169. In particular, the relationship  $\tan \xi = \frac{1}{2} \tan \varphi$  for straight line limited fields was known long before he read Dr. Heinrich Hintenberger's publications on the subject. The focusing of an ion beam by such a field is depicted in Figure 16 [ see page 72]. 25X1
170. It was evident that in order to realize experimentally such a reproduction (image), it would be necessary to devote special attention to the stray fields of the magnets, and also to take care that no larger bending of the stray fields or deflection of the stray fields from the terminal edge would occur. For this purpose, model tests were made and the stray fields were measured.
171. It was found that a sufficient dispersion of the terminal edge, that is, dispersion so that the terminal edge was approximately 50 times as wide as the beam, sufficed to make the two errors negligible. It was consequently decided to utilize such a field for what source referred to as a "technical Mass spectrometer." A technical mass spectrometer is a literal translation of technisches Massenspektrometer, a term used by source to designate an instrument designed for industrial use and suitable for mass production. The properties of this arrangement are compared with those of a conventional sector field of equal base length and nearly equal beam length [see Figure 17, page 75]. It is evident that the resolving power of the corrected sector field is, when the base is equal and the slit widths are equal, only approximately 95 percent of the standard sector field at a relatively large aperture of the ion beam. [Text continues on page 76]

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$$B = 600 \text{ mm} = 3r$$

$$r = 200 \text{ mm}$$

$$\varphi = 60^\circ$$

$$\epsilon' = \epsilon'' = -\frac{1}{2} \tan \frac{\varphi}{2} = 16^\circ 08'$$

$$g' = g'' = r \tan \frac{\varphi}{2} = 231 \text{ mm}$$

$$L = g' + g'' + r \varphi = 671 \text{ mm}$$

Dispersion along \$S\_2\$

$$\text{for } \frac{\Delta m}{m} = 1\%$$

$$D_{1\%} = r \left( \frac{1}{6} - \frac{1}{6} \cos \varphi + \frac{1}{3} \tan \frac{\varphi}{2} \sin \varphi \right) \cdot 10^{-2} = 1.167 \text{ mm} \quad D'_{1\%} = r' \cdot 10^{-2}$$

= 150 mm; therefore, \$D = 77.7\% D'\$ (same source slit to collector slit distance)

$$B' = 600 \text{ mm} = 4r'$$

$$r' = 150 \text{ mm}$$

$$\varphi = 60^\circ$$

$$g' = g'' = r' \tan \frac{\varphi}{2} = 260 \text{ mm}$$

$$L' = 672 \text{ mm}$$

Figure 17: Comparison Of Conventional Ion Optical System (b) With A Second-Order Corrected System (a)

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172. It ought, therefore, to be expected that a marked improvement would be encountered with the new field. This was later confirmed. Using an aperture of  $2 \times 10^{-3}$ , as is commonly used, the resolving power of the corrected field is only 80 percent of the uncorrected sector field. It is evident that the application of this process is no longer advantageous, since the magnetic field must be much more carefully measured and insulated. In the case of interference brought about by  $UF_6$ , however, it is unquestionably more advantageous to use a corrected field.

173. The technical execution of this project in Agudzeri brought with it unsuspected difficulties, as virtually all materials that were supplied in connection with the vacuum system were not vacuum-tight. Even the mercury diffusion pumps which had been imported had iron-casting boilers which developed leaks as soon as the lacquer had been burned off. Thereafter, it was impossible to achieve better than  $10^{-6}$  mm of mercury.

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174. The steel pipe that was supplied for the cooling traps could not be successfully brazed with hard-solder or welded, and during the first cooling of the material in liquid air, cracks would inevitably appear.

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175. In the end, they finally did manage to obtain vacuum-tight copper piping, and good steel was obtained in the form of old railroad axles out of which they then made the analyzer pipe and the cooling traps. In view of the fact that all the other parts had meanwhile been completed, including the two electrometers whose tubes (RCA Acorn 954) bought in New York, in 1938, the progress now made was accordingly very rapid.

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#### DESCRIPTION OF MASS SPECTROMETER

##### Ion Source

176. The above described Nier-type ion source was used. It was modified to the extent that a third accelerating electrode was utilized. The third electrode was employed in order that the aperture diaphragm ( $s_0$ ) be transferred into a field-free space. This caused the oscillations of the ion beam, resulting from the charge-up of the

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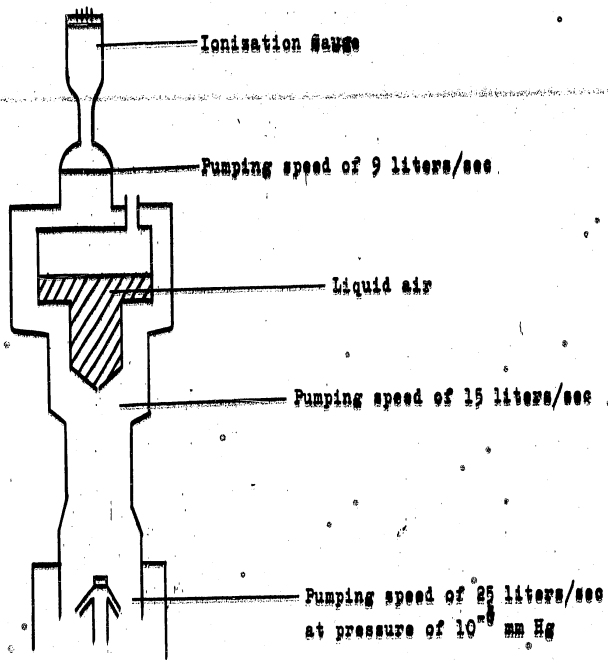
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interior surfaces of the aperture diaphragm, to decrease. It was about the time when the vacuum experiments with the new pumps were carried out that the first Soviet-made ionization manometer tubes, type *SM2*, were received, as well as the allied electric-operated measuring instruments. As these measuring instruments were, however, very unstable, new measuring instruments were locally designed and constructed. These locally made instruments kept the emission of the ionization manometer tubes constant ( $5 \text{ mA} \pm \text{one-half percent}$ ), and thus permitted considerably higher measuring accuracy. The Soviet manometer tubes had exactly the same dimensions as the tubes of the Distillation Products Co. in Rochester, USA, and were identical except that they had a nickel-sheet oscillator, instead of a platinum collector electrode, for ions along the glass walls. The Soviet version was very difficult to de-gas. The calibrating factors for the American and the Soviet tubes were identical within  $\pm 5$  percent, even though the Soviet tube factory would guarantee only  $\pm 10$  percent.

177. At first, some experiments were made with the diffusion pump which had been received [redacted] and a suitable cooling trap was developed. The pump speeds and pressures were measured; the arrangement for making such measurements is shown in Figure 18 [see page 78]. A hollow and internally cooled body was used as a cooling trap. The pressure limit, measured with the ionization manometer, was somewhere between  $3$  and  $5 \cdot 10^{-9}$  mm Hg. This indicated that the pump system and cooling effect would be sufficient for a mass spectrometer. It is evident that a pressure of from  $3$  to  $5 \cdot 10^{-9}$  mm Hg is obviously not to be taken seriously. It was evidently strongly falsified, as a result of the photoeffect of the ion collectors. Later it was found that an ionization manometer recording of  $3$  to  $5 \cdot 10^{-9}$  mm Hg in reality was equivalent to a pressure of from  $5$  to  $8 \cdot 10^{-10}$  mm Hg. This was found by measuring the ion currents of  $\text{N}_2^+$ ,  $\text{O}_2^+$ ,  $\text{C}_2^+$  and  $\text{Hg}^+$  in the mass spectrometer. Up to a pressure of  $\sim 8 \cdot 10^{-9}$  mm Hg, the recording of the ionization manometer is correct to  $\pm 10$  percent.
178. For the evacuation (pumping) of the mass-spectrometer tube, two pumping devices were used which were connected with a common (single) vacuum chamber and a rotating oil backing pump. The first pump served to evacuate the ion-source system, and the second evacuated the analyzer tube together with the target (electrode collector). In this fashion, it was possible to achieve in the mass spectrometer pressure of  $\sim 10^{-9}$  mm Hg, and the background became, in fact, very small.
179. The mass spectrometer which was later manufactured at NII-160 in Fryazino, never reached this goal, probably because the metal that was used there was slightly porous. The mass spectrometer analyzer tube was made of copper, and its bend in the central part was pressed [Text continues on page 79]

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**Figure 18; Pumping Speeds In Various Parts Of The Evacuating System**

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flat in order to make the magnetic gap as small as possible. Steel flanges were hard-soldered to the ends of the tube. Onto the steel flanges, in turn, the targets and the ion-source part could be screwed. Copper rings 0.2 mm in thickness were used as gaskets, after having first been cleaned and softened by being raised to red heat in a vacuum. In one of the flanges, a groove of approximately 0.6 mm depth was turned, and on the other a ring-shaped elevation of approximately 0.7 mm height was supplied. Details of this gasket are depicted in Figure 19 [ see page 80 ].

180. It is important that the two diameters coincide as far as possible. If screw-system material with the same thermal expansion coefficients as the flange material is used, then a very good and high vacuum-tight connection can be obtained, which according to Agudzeri experiments can be heated up to 600° C without developing leaks. The mass spectrometer was, as a rule, only heated up to 350° C, which was found to be sufficient for most routine work.
181. No valve was connected between the cooling traps and the mass-spectrometer tube. The reason was to prevent still further reduction of the pump speed, and to obviate the need to introduce gasket (sealing) material which would cause gas generation and thus lead to a reduction of the vacuum and consequently raise the lower strata. Obviously, mercury vapor will diffuse back into the mass spectrometer as long as there is no liquid air in the cooling trap. As, however, the mass spectrometer must be preheated at the beginning of every work process, this is hardly to be considered a drawback. On the contrary, it is possible now to begin the work process with warm and cooling traps and by means of the diffusion pump to pump out all gases and vapors (excepting, of course, Hg-vapor) so that only Hg-vapor will remain in the mass spectrometer tube. Upon the cooling of the cooling traps, the Hg will condense, and the cooling trap surfaces will not be covered with compounds (e.g., CO<sub>2</sub>) which are difficult to condense. The latter would give rise to undesirable pressure changes at every variation in the level of liquid air.
182. After working with very active chemical substances, it is possible, in fact, it is necessary, to bake out the spectrometer tube. Also, the gas that has condensed in the cooling traps is removed with warm air and pumped out with the aid of diffusion pumps.
183. It is expedient in this connection to set a cooling trap between the diffusion pumps and the fore pumps which would keep all condensable combinations away from the fore pumps. Such a cooling trap ought to be made so that it can be dismantled, and cleaned after operation. This method proved to be very satisfactory in work with UF<sub>6</sub> and BF<sub>3</sub>, and no failure occurred in the many years of operation except for operator-caused errors. By careful preheating at temperatures up to 450° C, even the Hg spectrum can be reduced to a point at which measurements of the relative abundance of the lead isotopes can be made with an accuracy of better than one percent. The work of Vinogradov and Zadorozhniy and others, reported at the July conference of the Moscow Academy, on the tests of various leads was done with one of the mass spectrometers (MS-3 or 4).

[Text continues on page 81]

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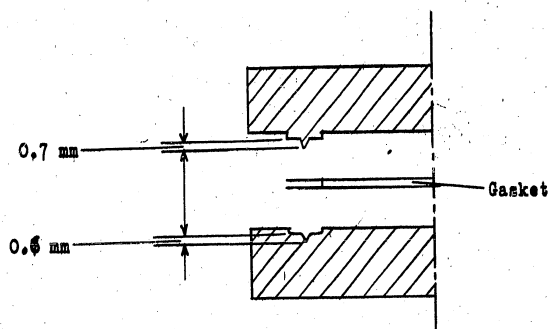


Figure 19; Detail Of Metal Gaskets Used In Vacuum System

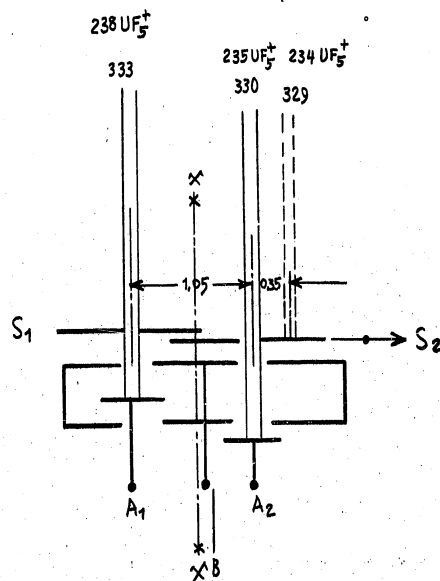


Figure 20; Collector Arrangement Used For Measuring Isotope Ratio

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184. In the course of one or two years, the vacuum in a mass spectrometer of this type becomes increasingly worse and many hydrocarbon background lines of the very heavy masses of  $\sim 220$  will appear. Their intensity is not very great and is notably constant. If a secondary electron multiplier is used as an ion detector, then these background lines will crop up again within two or three hours after the apparatus has been heated to  $480^\circ\text{C}$  which was the highest temperature that could be used in Agudzeri because of the molybdenum glass. After a few days of continuous pumping, the background lines are so large and numerous that the high sensitivity of the secondary electron multiplier cannot be utilized fully. The basis was found in the reverse diffusion of the oil of the backing pump, and was caused by the two cooling traps and the slow accumulation of the heaviest oil fractions, or their cracking residue, in the ion source.
185. When oxidizing the ion source with oxygen at 0.1 mm pressure and at a temperature of  $480^\circ\text{C}$ , the subsequent reduction of the metals with hydrogen will eradicate the background (substrata) for a few hours. This means that the full sensitivity of a secondary electron multiplier can be exploited, assuming, of course, that the sample or preparation to be examined is pure enough.

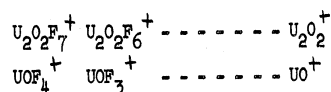
#### Ion Collectors For $\text{UF}_6$ Measurements and Cleaning Methods

186. The problem of simultaneous measurement of the two beams  $^{235}\text{UF}_5^+$  and  $^{238}\text{UF}_5^+$  contained in production grade  $\text{UF}_6$  without special cleaning, or with the use of very simple cleaning methods, gave rise to unexpected difficulties. It was not possible to utilize as simple a collector system as that described by Nier in the Review of Scientific Instruments 11, 212., 1940, because of the occurrence of interference lines. The principal interferences, no doubt, had their origin in the two admixtures to the  $\text{UF}_6$ :

- The occurrence of fluorine combinations containing oxygen,
- The presence of fluorocarbons.

Such conditions ought to be avoided very carefully during the early periods of the operation of experimental separation machinery.

188. If the mixture of  $\text{UO}_2\text{F}_2$ , a corrosion product of  $\text{UF}_6$  with water and  $\text{UF}_6$ , is heated in a separation stage, then there will be formed the somewhat transient mixture of  $(\text{UOF}_4)_2$ . This combination will yield in the ion source the following molecular ions:



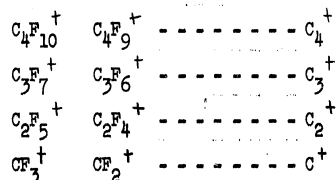
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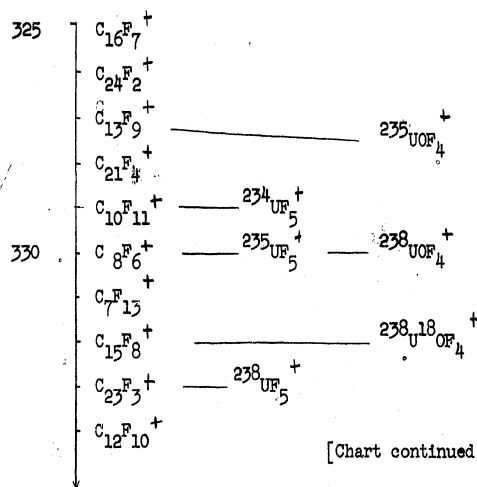
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189. Their presence has been experimentally confirmed. Of these, the ion  $^{238}\text{UOF}_4^+$  has the same mass as  $^{235}\text{UF}_5^+$  which is the most intensive ion in the ionization of  $\text{UF}_6$  that can be measured in practice. This is explained by the fact that  $\text{UF}_6^+$  is too weak and the  $\text{UF}_4^+$  becomes even more dissolved by the  $\text{UOF}_4^+$ , as the latter is even more intensive than the  $\text{UOF}_4^+$ . A very slight admixture of these oxygen-containing combinations is therefore able to alter the measurements considerably. A very careful resublimation of the  $\text{UF}_6$  sample does much to overcome this interference. In fact, one sublimation operation generally will lead to a measuring accuracy within one percent. The interferences caused by the ions of fluorocarbons, however, are considerably more difficult to remove.

190. The fluorocarbons  $\text{C}_x\text{F}_y$ ,  $x = 12$  to  $18$  and  $y = 16$  to  $38$ , are generally used in a gaseous-diffusion cascade for the purpose of greasing the ball bearings of the compressors. Also in a countercurrent diffusion cascade a mixture of fluorocarbons of the nature  $\text{C}_x\text{F}_y$ ,  $x = 8$  to  $14$  and  $y = 10$  to  $30$ , are used as a countercurrent gas. The ionization in the ion source, gives rise to all possible sorts of particles of these molecules which, in turn, lead to very many mass lines in the mass spectrometer. Even such a simple combination as  $\text{C}_4\text{F}_{10}$  yields a plurality of ions.



That is, there are 29 different ion types between the mass 238 and 12. Added to this are the various double and triple ionized particles which occur if the electron energy is adequate. It is no surprise, therefore, to find that with such complicated fluorocarbon mixtures as are used in these two types of cascades, in the immediate vicinity of the  $\text{UF}_5^+$  lines all masses are crowded with particles of fluorocarbons. For example:



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335	$C_{20}F_5^+$	
	$C_9F_{12}^+$	
	$C_{17}F_7^+$	
	$(C_6F_{14})^+$	not observed
	$C_{14}F_9^+$	
340	$C_{22}F_4^+$	

191. All lines which have been cited in the above samples were on occasion and with changing intensity observed, with the exception of the mass 338 belonging to the ion  $C_6F_{14}^+$ . The latter is the molecular ion (without being a splitting-off from fluorine) of the saturated fluorocarbon  $C_6F_{14}$ , and evidently does not occur in the mixtures. The higher members of  $C_{16}$  are generally very rare, so that an overlapping (superimposition) seldom arose for the masses of 330 and 333.
192. As the composition of the fluorocarbons used in the gaseous-diffusion cascade differed from those used in the countercurrent cascade, it was generally the case that different interference lines were encountered.
193. For the gaseous diffusion cascade, it was found in Agudzeri that it was principally the  $C_{15}F_3^+$  ion which interfered with constantly varying intensity. Furthermore, it was the ion  $C_{10}F_{11}^+$  which practically made the measurement of  $^{234}U$  an impossibility. In Verkhniy Neyvinskiy, it was found that both mass spectrometers were strongly contaminated with fluorocarbons, and that the enriched  $^{234}U$  could only be measured with an accuracy of  $\pm 10$  percent. The removal of the fluorocarbons that had intruded was found to be most difficult, evidently because of the gradual decomposition of polymerization products during the heating.
194. In the countercurrent cascade, it was found that the ion  $C_7F_{13}^+$  was especially active in interfering with intensities that were 10 to 20 times larger than those of  $^{235}UF_6^+$ . A connection of the mass spectrometer directly to the cascade was generally not used, although it would have done much to speed up the work. The ion  $C_{10}F_{11}^+$  was also observed, but it was less strong than in the first case.
195. On the rare occasions that the mass spectrometer was directly coupled to the cascade, the ions  $C_{18}F_6^+$  and  $C_{23}F_7^+$  were also observed, which indicated that the fluorocarbon was undergoing polymerization processes. Fortunately, the two principal interfering agents  $C_7F_{13}^+$  and  $C_{13}F_9^+$  were situated just between the two uranium lines, and the other "busy-bodies"  $C_{18}F_6^+$  and  $C_{23}F_7^+$  were easily removable by simple redistillation of the  $UF_6$  samples. Consequently, with a suitable design for the collector, a measurement was possible in spite of the presence of light fluorocarbons. sketch of the collector arrangement which was finally selected after numerous experiments is depicted in Figure 20 [see page 80].

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196. The slits  $s_1$  and  $s_2$  were punched into tantalum foil having a thickness of 0.05 mm and dimensions of 0.2 mm x 8 mm. The position of slit  $s_2$  in relation to the slit  $s_1$  was adjustable from the outside by means of a syphon and a micrometer screw. The targets (collectors)  $A_1$  and  $A_2$  were carefully and electrostatically shielded from one another by means of the diaphragm B. This diaphragm was charged to 180 V in order to suppress the secondary electrons. The entire collector system could be turned about the axis x---x so that the slits could be adjusted exactly parallel to the lines. The lines had a width of approximately 0.1 mm while the slits were 0.2 mm wide. Consequently all nearby interference lines, in so far as they were either heavier or lighter by one mass unit, could be eliminated.

#### Electrometer Amplifier

197. The electrometer tubes used in the nine mass spectrometers built by source were the RCA acorn tubes 954 and the Soviet copy of these tubes designated 6Ж1Ж. These tubes were operated with only 2.5 to 2.7 v instead of a 6.3 v filament voltage. The first grid received a potential of from +0.3 to +0.5 v against the cathode, and the second grid (the former screen grid) received a potential of +6.0 v. The retarding grid was used as a control grid. The anode potential was between 6.2 and 6.8 v. The grid bias was from -1.9 to -2.1 v. Under these conditions, approximately 10 to 20 percent of the tubes had sufficient emission, and evidenced grid currents of the magnitude of  $5 \cdot 10^{-15}$ , and sometimes even up to  $10^{-16}$  A. The minimum for the grid current occurred at a grid bias of -2.0 v to -2.3 v, as indicated in Figure 21, [see page 85]. At this place, the slope of the emission characteristic of the tube with  $R_a = 250 \text{ K}\Omega$  was of the order of 0.5 to 8  $\mu\text{A}/\text{v}$ , so that the voltage amplification was still somewhere between 1.5 and 2.0.
198. It was found that the grid current for the Soviet tube, type 6Ж1Ж, was on the whole approximately 50 to almost 100 percent smaller than the American tube 954, of which [ ] approximately 200 at [ ] disposal. The reason for this is probably that the Soviet tube's emission was noticeably lower than in the American tubes. Evidently the process of forming the cathode had not been carried out as well in the Soviet Union. 25X1 25X1
199. Prior to the assembling of the tubes in the mass spectrometer, they were carefully cleaned with gasoline, alcohol, and distilled water in succession in order to remove all surface contamination. Measurements were then made at a pressure below  $10^{-4}$  mm Hg. This low pressure was used after it had been discovered that the thin layers of water, which caused a time change in the grid currents, could not be removed with sufficient certainty at higher pressures. This procedure obviated the need for protective rings necessary for the introduction of the third grid. This third grid, usually in form of an aquadag coating, would only unnecessarily increase the capacity. The circuit of the tube-electrometer amplifier was to some extent different of that of Nier. This was necessary because a different feeding for the electrometer tubes was used. Details of the difference were not remembered by source, [Text continues on page 86]

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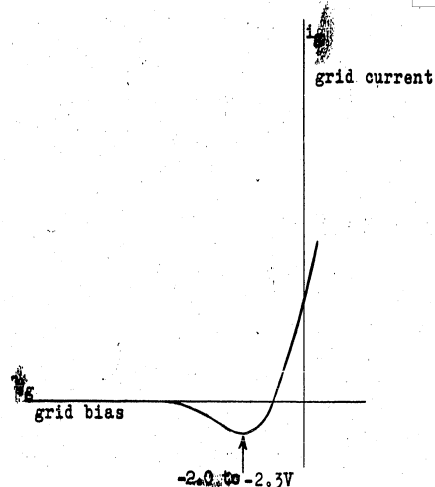
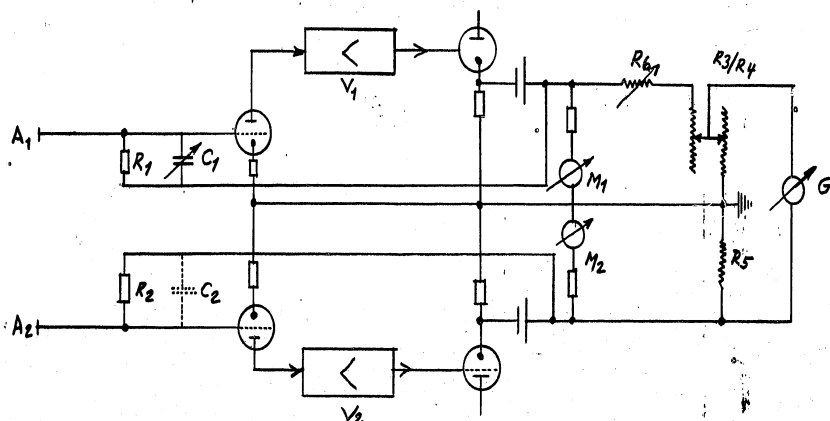


Figure 21; Characteristic Curve Of Acorn Electrometer Tube  
(RCA 954 or Soviet 6) (1) (1)



$A_1$  - Collector for the larger current.  $R_1 = 10^{10}$  Ohm

$A_2$  - Collector for the smaller current.  $R_2 = 9.5$  to  $9.9 \times 10^{10}$  Ohm

$V_1$   
 $V_2$  } D.C. Amplifiers

$M_1$   
 $M_2$  } Indicators for coarse intensity measurement

$R_3/R_4$  Decade potential dividers (put-and-take form)

$R_5$  10 kilo ohm resistance in order to make the loading of the two amplifiers equal

$R_6$  Compensation resistor to decade potential divider

G Null galvanometer

Figure 22; Schematic Diagram Of Circuit Used With Double Receiver Collector

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but the principle used was the same as Nier's. The initial voltage of the electron tubes was transferred to one each of the direct-current amplifiers, while the initial voltage of the direct-current amplifier was led back to the input grid in the form of negative feedback. The over-all amplifying factor, without feedback, was approximately 20,000. Consequently, the voltage-reduction ratio with an accuracy of 1/20,000 was equal to unity.

#### Measuring Principles

200. The collector for the stronger ion currents was connected to one electrometer by a resistor of  $10^{10}$  ohms, while the collector for the small currents was connected to the other electrometer by a resistor of  $10^{11}$  ohms. In this selection of the second resistor, care was taken to make sure that it was a few percent less than exactly 10 times that of the first resistor. A schematic diagram of the circuit used is given in Figure 22 [see page 85]. In Figure 22,  $R_6$  is adjusted so that:

$$\frac{10 R_1}{R_2} = \frac{(R_6 + R_{11})}{R_5}$$

Under these conditions the decade potentiometer will indicate exactly 10 times the ratio of the currents to the collectors  $A_1$  and  $A_2$ .

201. In making uranium measurements, the voltage divider was usually adjusted to 0.0720 and the resistance  $R_6$  was varied until the galvanometer G registered zero; 0.0720 is ten times as much as 1/139, and is thus the current ratio to the targets (collectors) when working with natural uranium. When working with altered samples, it is possible to read off directly the ratio corresponding to relative abundance. This had proven satisfactory when using unskilled operators on the mass spectrometers. The physicist supervising a number of mass spectrometers need only note one figure for all instruments.  $R_6$  remains outside of the purview or jurisdiction of the laboratory assistant.
202. The condenser  $C_1$  has the function of making the time constant of the two electrometers as equal as possible:  $R_1 \cdot C_1 = R_2 \cdot C_2$ , where  $C_2$  represents the self-capacitance of the second electrometer. In practice, this was usually done as follows: The galvanometer G, if the ion currents are switched on and off and if the compensation for the current relationship is correct, will make only such deflection as will correspond to a change in the current ratio of 1/10,000. This condition is fairly easily satisfied by simply switching a condenser of three to four micromicrofarads in parallel with  $C_2$ . It appeared as if this was somehow connected with the stray inductance (capacity) of the collectors  $A_1$  and  $A_2$ , but the phenomenon was not further investigated in Agudzeri.

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203. The adjustment of the interval of the collectors was also performed by observing the zero-galvanometer  $G$ , and in such a way that the plateau was as wide as possible. When the mass spectrometer was in a good condition, a plateau was obtained that was considerably wider than the individual plateau for the lines  $^{238}\text{UF}_5^+$  and  $^{235}\text{UF}_5^+$ .
204. In Figure 23 [see page 88],  $i_{\text{m}}$  represents the recording of the instrument  $M_1$  as a function of the magnet's current  $i_{\text{m}}$ .  $\omega_G$  of the zero-galvanometer's deflection is shown as a function of the magnet's current  $i_{\text{m}}$ . The deflections for  $\omega_G$  in a positive direction are such that the current for the line  $^{238}\text{UF}_5^+$  predominate. This means, that the line  $^{238}\text{UF}_5^+$  is considerably broader than the line  $^{235}\text{UF}_5^+$ . If the acceleration voltage of 2,500 v, which is ordinarily used, is reduced to 1,000 v, then the deflections will become two to three times as high. The negative deflections for  $\omega_G$  originate from a residue of energy-rich secondary electrons which have been formed along the diaphragm's edges. If the distance between the collector slits is very carefully adjusted, the plateau of the galvanometer deflection will be so wide that the decimal potentiometer will record a deviation of 0.1 percent only when the line-intensity has dropped by one-third to one-fourth.
205. The two side-peaks of the galvanometer deflections will then be of equal height within  $\pm 10$  percent. The achievement of this condition, by means of the ion-source magnet adjustment, the extraction potential of the ion source, and the slit interval for standardized parameters of the mass spectrometer, was regarded as the criterion for its measuring accuracy and reliability. These adjustments had to be repeated each time after baking out the instrument, and were always done with the purest possible  $\text{UF}_6$  prior to beginning a new sample-measuring series. In view of the fact that the fluorocarbon lines which were superimposed on the uranium lines had masses that were heavier by as much as 0.05 to 0.09 mass units, a fluorocarbon superimposition was immediately recognizable. Such impurities were quickly detected by the narrowing of the plateau and the ever greater asymmetry of the side-peaks of the zero-galvanometer. Once recognized, these measurement results could be disregarded, and the samples were purified by repeated redistillation until the side-peaks recorded normally. If  $^{235}\text{UF}_5^+$  was hindered by  $\text{C}_{18}\text{F}_6^+$ , then the peak, associated with the larger  $i_{\text{m}}$ , became negative. Again, it was easy to recognize this admixture, that is, the presence of this impurity. Only in one instance would it have been impossible to recognize the error, namely, if both uranium lines were superimposed on fluorocarbon lines that accidentally had the same intensity ratio as the two uranium lines. Obviously, this phenomena is rare. It is not possible by this means to recognize the superimposition of  $^{235}\text{UF}_5^+$  by  $^{238}\text{UF}_5^+$ , resulting from the small differences in their masses. These impurities frequently led to erroneous measurements, especially if the laboratory personnel was not careful with the redistillation of samples especially smaller samples. As an example, it might be mentioned that the small samples which Max Steenbeck in Sincp sent to Agudzeri for mass spectrometric measurement were usually contaminated with oxygen. The laboratory personnel, fearing that they might lose the sample during the distillation process, or that they might further contaminate the sample, more often than not only partially cleaned the samples.
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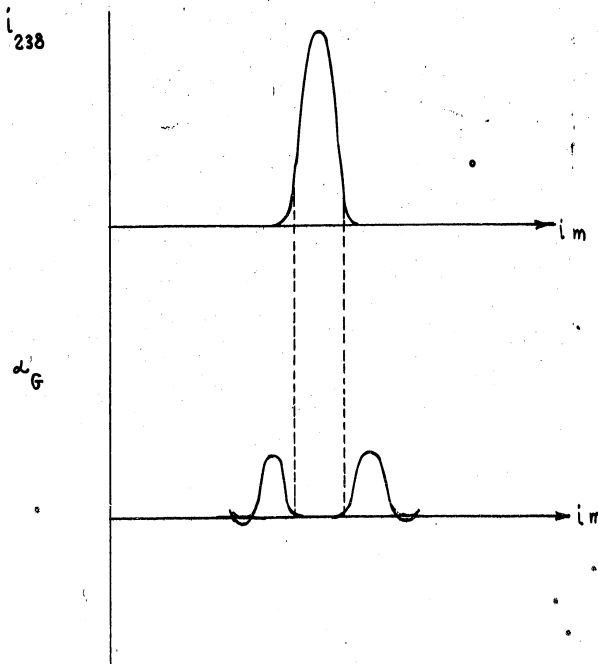


Figure 23; Magnetic Scanning Of Ion Peaks

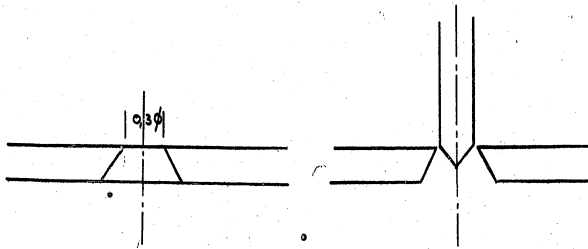


Figure 24; Detail Of Needle Valve

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#### Gas-Intake System

206. The gas-intake system used for the uranium measurements consisted of a simple needle valve which transmitted the gas from a storage pocket of  $\sim 100 \text{ cm}^3$  capacity to the ion source by way of a short tube with a diameter of approximately five [millimeters]. The pressure in the storage pocket was kept constant by means of a cold bath of  $-60$  to  $-80^\circ \text{C}$ . This arrangement was selected, because the separation effects during the effusion through a very small hole are very small for a heavy gas such as  $\text{UF}_6$ . Obviously, it would have been better to work without a needle valve and with only a hole punched into a thin foil. This, however, would have caused difficulties in temperature adjustment and in maintenance of constant pressure. Thus, in order to be somewhat independent of the pressure, a needle valve was selected, and the thickness of the disk in which the needle rested was made as thin as possible, approximately 1.5 mm. This meant that only a very short capillary with a circular outlet which acted as a filter, provided a resistance to the flow. The needle valve was made of steel, one mm in diameter, and the hole was punched into a disk of soft nickel sheet with the aid of a needle. The hole was then ground smooth. After the hole system had been soldered into the valve-body, the hole was somewhat widened with the valve needle until it assumed exactly the form of the carefully polished steel needle. Valves of this type were extraordinarily airtight, and pressures of  $10^{-8}$  mm Hg or even less in the ion source could be obtained with them.
207. Using  $\text{CO}_2$  as testing agent, these valves still registered 10 to 15 percent of the elemental separation effect, when used opposite a hole of 0.01 mm diameter in a 0.01 mm platinum foil. An error of this magnitude is naturally of no significance in uranium measurements, since the uranium measurements made use of only a relative method.
208. An experiment was made in Agudzeri which involved the building of a needle valve without separation effect. It could be regarded as successful in so far as the purely physical aspects are concerned. For this purpose a tungsten-carbide plate of 0.3 mm thickness was taken, and a conically shaped hole of .3 mm diameter was drilled into it. The hole was drilled with an iron needle and was polished with boron carbide until the edges were very sharp. A sketch of this arrangement is given in Figure 24 [see page 88]. Into this hole was lowered a very slender steel needle, so that only approximately 0.1 to 0.2 mm extended into the hole. The valve, which was provided with a lever for precision adjustment, regulated very well, and the separation effect, measured with  $\text{CO}_2$ , was very small, if present at all. The valve, however, could not be sealed tight and finally broke during one of these experiments. No attempt was made to build a second valve in the same manner.

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-90-Deflection Magnet

209. The first mass spectrometer was provided with a very small magnet with a low-voltage winding. This was necessary because of iron and copper shortages. A sketch of the magnet is given in Figure 25 [see page 91].
210. The magnetic characteristics of the iron were poor and caused very strong hysteresis and an heterogeneous field in the air gap. The magnets for the mass spectrometers subsequently built by source, that is, MS-0 to MS-9, as well as the mass spectrometers built by the Soviet factory NII-160 in Fryazino, were considerably improved and are believed to be adequate for their intended application. A rough sketch of these magnets is given in Figure 26 [see page 92].
211. The pole shoes were made of Armco iron (called thus also in the USSR) which was first treated with hydrogen and then annealed at a temperature of 950 to 1,000° C for a period of 24 hours. This treatment produced satisfactory field homogeneity as well as a very regular falling off of the stray field. Thus, the prerequisite for a focusing of the second order was satisfied.
212. The excitation of the magnet coil was provided by a rectifier of 900 v and 600 mA. The regulator was designed so as to keep the current through the magnet constant, and insured that temperature changes in the magnet would effect changes only in the air gap dimensions and the permeability of the core, but not in the current. These, however, were much smaller effects than the changes in the resistance of the windings.
213. The adjustment for the different masses was performed only within the magnetic field. For this purpose, the magnetic field control was divided into 10 regions by means of the switch  $S_1$  and then continuously by means of the three resistors  $R_1$ ,  $R_2$ ,  $R_3$  for coarse, medium, and fine. Figure 27 is the circuit which was used for this purpose [see page 93].
214. All resistances  $R_1$  to  $R_4$  were made of constantin wire and were of such dimensions that they would heat up only to approximately 50° C. It was recognized that manganin wire would be more desirable, but this wire was not available. The switch  $S_2$  served the purpose of adding groups to the control tubes, depending on the current needs. Groups of 6  $\Pi 3$  are equivalent to the 6L6 in triode arrangement. This means that an adjustment, especially at the lower end of the characteristic curve is avoided, and this leads to higher accuracy. The precision of adjustment generally obtained was in the neighborhood of  $10^{-5}$ , but was very much dependent on the quality of the 6  $\Pi 3$  tubes. It frequently occurred that the 6  $\Pi 3$  tubes generated gas during the operation and then became unstable. The high inductivity of the coil and the rapid oscillations of the tubes was, of course, most annoying. Automatic adjusters for small adjustment ranges can be connected at  $X_1 - X_2$ . A motor driven potentiometer was connected in place of  $R_4$  for the adjustment over the entire range. The collector of the potentiometer would then be connected with  $X_1$ .

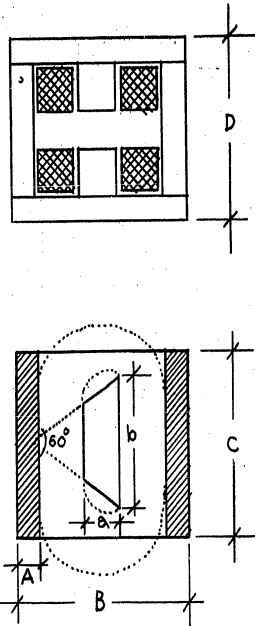
[Text continues on page 94]

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A = 30 mm

B = 200 mm

C = 250 mm

a = 50 mm

b = 155 mm

for ion beam radius  $r = 150$  mm

Material: ordinary construction steel

coil wound with 2.5 mm dia copper wire double

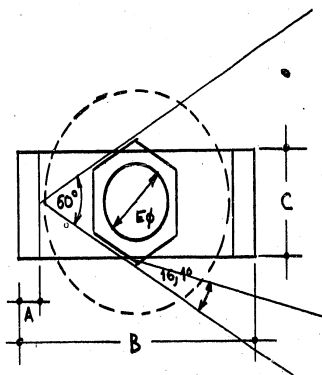
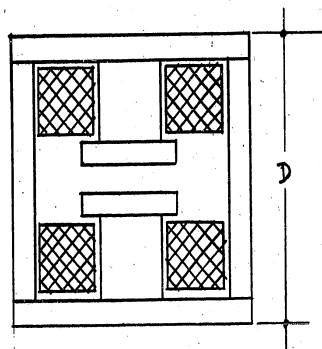
cotton insulated, for 24 volt battery operation

Figure 25; Mass Spectroscope, Dimensions Of Deflection Magnet

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A = ~40mm

B = ~400 mm

C = ~150 mm

D = ~500 mm

Eφ = ~120 mm φ

Material: ARMCO - IRON

(is also designated by this name in USSR)

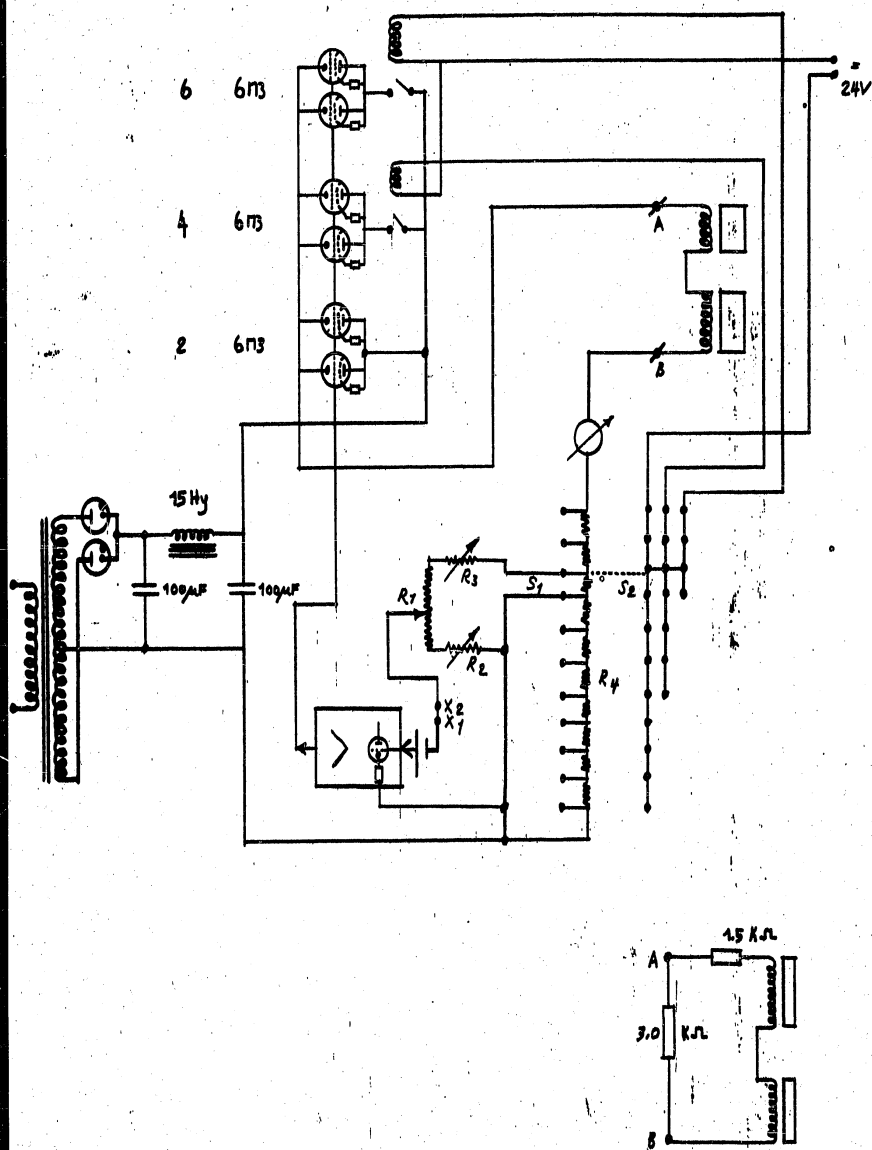
Coils, each 28,000 turns

0.69 mm diameter copper wire, enamel insulated,  
wound in layers, and insulated between layers  
by oil paper 0.1 mm thick

Figure 26; Second Mass Spectrometer, Details Of Deflection Magnet

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**Figure 27: Circuit For Scanning Mass Range By Varying Magnetic Field**

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215. A large condenser served in many experiments as an adjustment device for smaller ranges. This 10  $\mu$ F condenser, which was charged in one or the other direction by means of a high resistor, was connected between  $X_1$  and  $X_2$ , as shown in Figure 28 [see page 95]. Because of the grid-current of the amplifier, it was usually necessary to use two different resistors in order to achieve the same speed of adjustment in both directions. It might be noted at this point, that the adjustment device

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\_\_\_\_\_ were also connected at  $X_1$  and  $X_2$ .

216. With this instrument, all masses from approximately two to approximately 600 could be analyzed at a maximum acceleration voltage of 2,500 v. The acceleration voltage then had to be turned down to 1,000 v, so that the masses from approximately five to approximately 1,500 could be picked up by the magnet's regulation. So as to be able to turn in also for a mass of one, the magnet was connected to the terminal A and B, not directly but rather by way of a voltage divider. Thus the instrument will now embrace a mass range from one to 1,500 subdivided into three ranges: from 1 to 300, 2 to 600, and 5 to 1,500. To prevent destruction of the magnet's winding as a result of overloading when the switch 1 was operated, the following was provided: The winding was mounted on a spool of 5-mm thick brass sheet and covered by a carefully short-circuited copper sheet 0.5 mm thick. This short-circuited winding would dampen the rate of change of magnetization to such an extreme that the magnet could actually be cut out by the full load.

#### Mass Indicator

217. Laboratory assistants with little experience frequently experience difficulties with the determination of the mass number from the adjusted lines during a gas analysis. This is especially true for a mass spectrometer with a constant acceleration voltage, in which the magnetic field must be altered for the various different masses. The iron of the magnet, however, is not free of hysteresis, so that the currents for the adjustment will differ for one and same mass, depending on whether smaller or larger masses had been earlier adjusted on the machine. It is, therefore, necessary to measure the magnetic field directly. This is best done with a coil that swings or rotates within the magnetic field and whose voltage is proportional to the strength of the magnetic field. Thus, the adjusted mass will be proportional to the square of the voltage. For a single reading this square rule is not very desirable. For taking mass readings, it might be more ingenious to make use of the semiconductor effects which are proportional to the magnetic-field strength. Unfortunately, however, all known effects are coupled with very high temperature-coefficients, so that its range of application is very limited. For this reason a system based on a pickup coil was developed in Agudzeri, which exhibited very great accuracy. \_\_\_\_\_ sketch of the circuit used is given in Figure 29 [see page 95].

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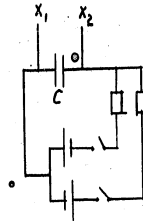


Figure 28; Adjustment Device for Smaller Ranges

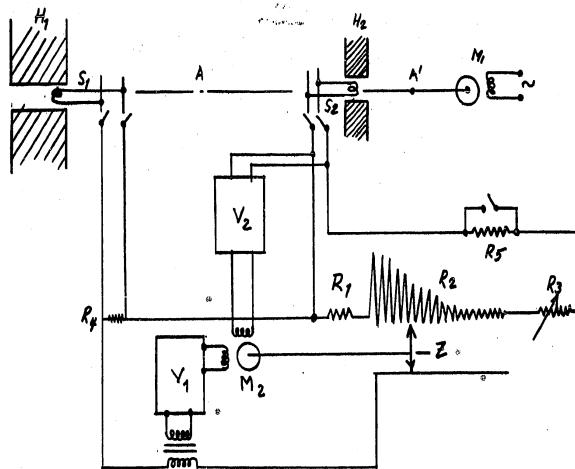


Figure 29; Current Diagram of Mass Recorders

- $AA^1$  = Axis of rotation of pickup coils.  
 $S_1$  = Pickup coil rotating in analyzer magnet field.  
 $S_2$  = Pickup coil rotating in constant magnet field.  
 $H_1$  = Magnet of Analyzer  
 $H_2$  = Auxiliary Magnet.  
 $R_1, R_2, R_3, R_4, R_5$  = Resistors.  
 $M_1$  = Motor for rotating pickup coils.  
 $M_2$  = Motor for moving contact to  $R_2$ .  
 $V_1, V_2$  = Amplifiers.

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218. Two coils  $S_1$  and  $S_2$  in the magnetic analyzer field  $H_1$  of the mass spectrometers  $M_1$  and  $S_2$  in the field of a constant auxiliary magnet  $H_2$  rested on an axis  $AA'$  which was driven by an induction motor  $M_1$  at approximately 1,000 rpm. The induced voltages were compared with another by means of an automatic compensation device. For this purpose, an induction motor  $M_2$  was used, the windings of which were fed by way of the amplifier  $V_2$  from the induced voltages of the coil  $S_2$ . The other winding was excited by the amplifier  $V_2$  by means of the differential voltage coming from the coil  $S_1$  and the scanned part of the voltage divider  $R_1, R_2, R_3$ . It turned the motor, depending on the phase of the voltage difference, in either one or the other direction until the position of the indicator  $Z$  indicated that the difference was zero. The resistance  $R_2$  was designed in the form of a quadratic winding, so that the readings of the masses would be linear. The resistance  $R_1$  served to lower the zero-point, as otherwise the resistance  $R_2$  would have had to be too large; and the resistance  $R_3$  served to adjust to a known reference mass.  $R_2$  had to be changed when the acceleration voltage was changed, and its registration, for example, could be calibrated directly from the volt-acceleration voltage. The resistance  $R_1$  had to load the coil  $S_1$  exactly the same amount as  $S_2$  was loaded by  $R_1, R_2, R_3$ . This was to prevent excessive distortions of the voltage curves between the two voltages. The adjustment of the phase position of the two voltages was assured by rotation of the auxiliary magnet  $H_2$ . By means of  $R_3$ , which could be shorted out, it was possible to adjust from two measuring ranges:  $M$  from 1 to 20; and  $M$  from 10 to 250. The measuring accuracy for the Mass 200 amounted to approximately  $\pm 0.2$  mass units, if the line  $N_2^+M = 28.0$  was selected as the initial mass.
219. If  $R_3$  were adjusted according to the lines  $H^+ \sim 1.008$  or  $H_2^+ \sim 2.016$ , then the error would be noticeably larger, as the coil  $S_1$  was located inside the deflection field of the ion beam and therefore had to traverse the stray fields of the magnets. These stray fields, however, increase considerably with increasing magnetization. The error could be eliminated if the coil  $S$  was devised in such a way that approximately one-third of it was located in the magnetic field and two-thirds ~~was~~ outside it. Then the error in the mass range between  $H^+$  and  $Hg^+$  would be smaller than 1/1,000 of the recorded mass unit. The weak points of the design were the slip rings for the reception of the voltages, which in time changed their resistance and which upon heating would produce variable thermal voltages. In Agudzeri, the slip rings were not used. Instead, short circuit rings or metal disks of manganin in order to eliminate the temperature influence, were permitted to rotate. Around these disks or rings, rigid coils  $S_1$  and  $S_2$  were mounted, in which the voltages were then induced. Another variation of this arrangement which would permit the coils, rotary oscillations was generally thought to be impracticable because of the high moments of inertia, especially for the required fixed axis, but it worked well when made in Agudzeri.

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High-Voltage Supply

220. Figure 30 [see page 98] is a sketch of the circuit used in the high-voltage unit for the production of the ion's acceleration voltage and the electrostatic analyzer voltage. With the switch  $S_1$  it is possible to regulate the extraction potential for the ions from 0 to 350 v in seven stages of 50 volts each. °
221. The potentiometer  $P_3$  permits a continuous regulation of the voltage at the electrode  $E_2$ . By means of potentiometers  $P_1$  and  $P_2$  counter-rotating on one axis, the direction of the ion beam was adjusted. The beam could be switched off by means of the switch  $S_2$ , which connected a deflection voltage to the condenser between the slits  $S_0$  and  $S_1$ .
222. The mass spectrometers MS-0 to MS-9 inclusive, as well as the first factory-made models, were provided with this circuit. At a later stage, however, the expensive high-voltage transformers were replaced by a high-frequency type of power supply which was controlled by way of the screened grids. All the later models of the instruments manufactured by NII-160 were supplied with this latter type of high-voltage supply. °

Ion-Source Supply

223. The circuit used for the power supply of the ion source is shown in Figure 31 [see page 99]: The electron-bombardment current of the ion source regulates by way of the tube  $L_2$ , the plate resistance of the tube  $L_1$  which loads the transformer  $T_3$ . As a result, the series impedance of the transformer  $T_4$  is changed, and the heating of the incandescent cathode of the ion source is regulated. The power developed in the series impedance will be released in the tubes  $L_1$  in the form of anode dissipation. ° The transformer  $T_1$  must be carefully shielded, so that no interferences coming from the line supply are transferred to the acceleration voltage. The electron energy can be adjusted for two ranges: from 0 v to 75 v and from 75 v to 150 v, by means of the switch  $S$  and the potentiometers  $P_1$  and  $P_2$ . The potentiometers are mounted on one axis and are counter-rotating. The electron current is controlled with the aid of the resistor  $R$ . The capacity of the hot cathode (tantalum) amounted to approximately 2.5 A at 1.2 v; approximately 3 watts at 200  $\mu$ A emission. If the cathode burns out, a small bulb  $L_3$  will light up. During experiments with  $UF_6$ , it was frequently found satisfactory to connect the electron collector directly to the cathode. It was also possible to mount a second cathode in place of the collector, which would permit the operation to continue without interruption in case the first cathode failed. When this happened, the second cathode became a collector. The Soviet colleagues or assistants of Chekhovtsov, 25X1 Shakhov, and Meyzerov, were very proud of "inventions" of this sort. Indeed, the system proved to be very efficient, and source once worked with one cathode for more than 1,000 hours without noting any disturbances whatsoever.

[Text continues on page 100]

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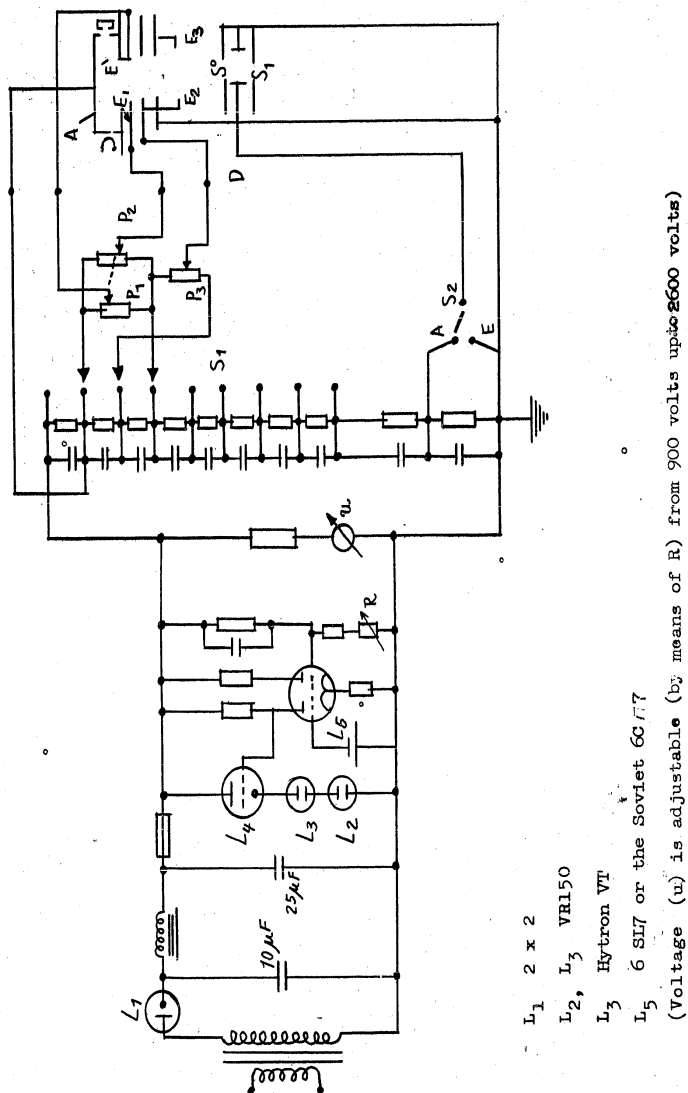


Figure 30; High-Voltage Supply Circuit

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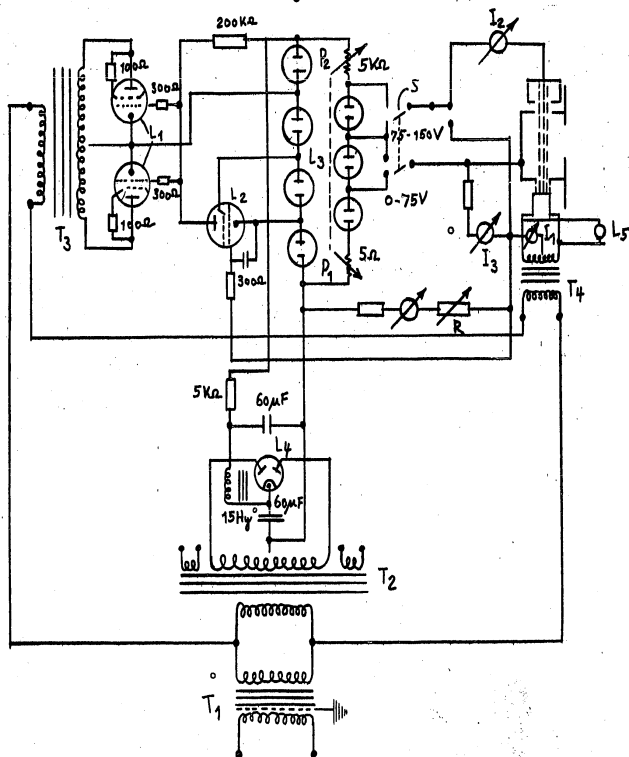


Figure 31; Power Supply for Nier-Type Ion Source

- |   |   |
|---|---|
| L <sub>1</sub> 6N3 equivalent to 6L6 (2 required) | I <sub>1</sub> Total emission 0 - 1 mA  |
| L <sub>2</sub> 6X7 equivalent to 6J7              | I <sub>2</sub> Electron energy 0 - 75 V |
| L <sub>3</sub> VR75 (7 required)                  | 0 - 150 V                               |
| L <sub>4</sub> 5Y4C                               | I <sub>3</sub> Beam current 0 - 1 mA    |
| L <sub>5</sub> 6.3 V bulb 0.08 amp.               |   |

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224. The ionization manometer was fed by power supplies similar to the ones described above. No Soviet factory was producing tube electrometers or regulated ionization gauges, but as the demand for these became ever greater, NII-160 finally developed one, and in 1952 began to manufacture ionization manometers and vacuum-tube electrometers. These were a simplified version of the type found in the mass spectrometer. According to statements by Shakhov, made on the occasion of a visit to Agudzeri in January 1955, the ionization gauges especially were produced in large numbers.

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225. In addition to this ion source, which was primarily used for  $UF_6$  measurements, a whole series of other ion sources was developed after 1950 and was tested. Briefly, these were of the following types:

- a. Ion source with electrostatic focusing of the electron beam in order to prevent separation effect upon the measurement of light masses.
- b. Ion source with temperature control for the ionization chamber and space-charge control for the cathode to be used in organic chemical analysis.
- c. Ion source with hot anode.

#### Ion Source for Light Masses

226. When measuring light masses, especially in isotope analysis, interferences are often encountered in the measurement of the intensity ratio of the lines. These interferences are the result of the electron beam's magnetic focusing field. On the one hand, the highest possible field intensity for the guide-field is desired for the production of a limited ionization volume and a high current density of the electron beam. Then the ion currents will be as large as possible, and the speed distribution as small as possible. On the other hand, however, it will not be possible to prevent a penetration of the guide field into the ion's acceleration path. This will cause different masses to have different predeflections, and may thus falsify the intensity ratio. This is especially true if the emission distribution of the cathode is not uniform and consequently, the current density distribution is not uniform.

227. It is for this reason that, for very precise isotope-determination tests the guide field was omitted, therewith accepting the corresponding intensity reduction. An increase in the pressure compensated for the drop in intensity. Under these conditions, how-

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ever, the ionization box becomes contaminated much more rapidly, since the electrons break up the molecules that had been adsorbed along the walls and formed insulating layers. The mass spectrometer must, therefore, be cleaned more often, and thus the operating time is reduced. Experiments were made to avoid this separation effect by introducing an electrostatic focusing of the electrons without, however, incorporating the aforementioned disadvantages. Between the cathode and the ionization box, a diaphragm was placed which was held at a slightly negative potential with respect to the cathode. This potential was adjusted so that the current to the collector was at maximum. By varying the cathode's temperature, it was, moreover, possible to make the electron current flowing to the ionization box at a minimum. With a favorable interval from cathode to diaphragm to anode and a favorable diaphragm diameter, it was possible to obtain a current to the collector that was 98 to 99 percent of the cathode's emission current. The cathode's temperature was only 100° above usual value. The ion currents that were thus obtained were only 10 to 15 percent smaller than those obtained upon the use of a magnetic guide field of 300 oersteds.

228. To test for separation effects, the following procedure was applied: In a small oven of the ion source, LiBr or LiI was evaporated and the ratio of the streams of  $\text{Li}^+$  and  $\text{LiBr}^+$  was measured. By applying a magnetic field, it was possible to measure this ratio with the magnetic guide field. The diaphragm was mounted on the ionization box. It was also possible to remove the entire magnetic field, and the diaphragm could be connected to a slightly negative voltage relative to the cathode. The electron current was approximately 250  $\mu\text{A}$ , with a guide field of approximately 600 oersteds; the ion currents were roughly twice as great as with electrostatic focusing. The ratio of the relative abundance with  $\text{Li}^+$  and  $\text{LiBr}^+$  or  $\text{LiI}^+$  in the case of electrostatic focusing amounted to:

$$\frac{\frac{7_{\text{Li}^+}}{6_{\text{Li}^+}}}{\frac{7_{\text{Li Br}^+}}{6_{\text{Li Br}^+}}} = 1.00 \pm 0.01$$

229. In the case of magnetic guiding, it was possible, by shifting the field in the direction of the ion beam, and by the slight tilting of the field in the plane defined by the ion beam and the main field, to arbitrarily obtain values between 0.96 and 1.05. But these values could be adjusted or reproduced. If no changes were made in the adjustment of the magnet, the values, as in the above case, remained constant up to at least one percent.

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230. When electrostatic focusing of the electrons was used, it was not possible to influence this ratio by any parameter changes whatever at the ion source. In spite of this relatively favorable result, some difficulties were generally encountered with this device.
231. In mass spectroscopy, it is frequently necessary to change the energy of the electrons in the ion source. For example, this is necessary in order to identify an interference superimposition, or in order to record an ionization function. Electrostatic focusing, however, requires a constant relationship between anode voltage and diaphragm voltage. The diaphragm voltage should be produced in a manner similar to that depicted in Figure 32 [see page 103]. As voltage drops along the cathode resistor  $R_c$ , the focusing will change as a result of emission variations during anode-voltage fluctuations. The changes in the emission are the result of changes in  $R_c$ , and the changes in the anode voltage are the result of the manipulation of  $S$  and  $R_a$  and  $R_p$ . In any event, it becomes necessary in both cases to adjust the electron beam focusing. In order to accomplish this refocusing quickly and easily, it is necessary that, in addition to measuring the current to the collector  $I_c$ , the current to the anode box  $I_a$  be measured. For this operation, a second measuring instrument is required. Alternate possibilities for the production of the diaphragm voltage must undergo the same analysis, e.g., an auxiliary battery or voltage divider mounted parallel to the diode path and the rheostat  $R_a$ . Ultimately, it must be accepted that the operation of a mass spectrometer becomes ever more complicated, and that the operators will frequently make errors.

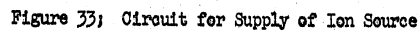
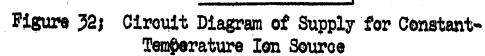
#### Ion Source with Temperature Control

232. For the purpose of organic-chemical analysis, the two ion sources that have thus far been described are not suitable. This is because in both ion sources the temperature in the anode box is not regulated and, above all, is not constant because of temperature changes in the cathode during control processes. During temperature changes of the gas which is to be ionized, the intensity ratio will, in a few cases, change quite considerably. On the other hand, the work function of the electrons leaving the cathode will also vary considerably with the gas mixture. Consequently, if constant emission is required, temperature changes in the cathode become inevitable. The effect is particularly pronounced when one transfers from oxygen-containing substances to  $UF_6$ . In this case, as the result of a formation of  $U$ -layers on the cathode, the work function drops to a value comparable to that of a thoriated cathode. The temperature of the cathode drops from about  $2,300^\circ K$  to below  $1,700^\circ K$  while the emission remains the same. While it is true that such pronounced change does not occur in hydrocarbon analysis, marked temperature changes are nevertheless encountered when working with oxygen-containing and halide-containing compounds. These temperature changes reduce the accuracy of the analysis.

[Text continues on page 104]

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For this reason, an ion source was developed in which the temperature of the cathode would remain constant and so high that, even with gases which strongly increase the work function, sufficient emission would be achieved. Between the anode and the cathode, a diaphragm was attached which was kept at a negative potential in relation to the cathode. The field in front of the cathode was lowered to a point at which the electron current was space-charge limited. By regulating this potential, the electron current was held constant. At the same time this diaphragm focused on the electron current, even though this effect would not be constant because of the control process. For this reason, it would suffice to provide an additional magnetic guide field from 50 to 100 oersted for the electrons. As a result, the separation effect in the ion source would become very small, which in turn would have most favorable effects for a very wide mass range, when used in analytical instruments.

234. Since in analytical instruments the electron energy is generally held at approximately 70 eV, the simple control schematic for supplying the ion source depicted in Figure 33 [see page 103] was used. The emission of the cathode K was adjusted to about two or three mA by means of the resistor  $R_1$ , after first short-circuiting the variable resistor  $R_2$  with the switch S and after connecting the diaphragm B with the anode A. The current supply at a, b, was provided by a constant-voltage transformer. After S was operated, the electron current was adjusted by means of the resistor  $R_2$  and was held constant at  $\pm 0.5$  percent. This was the case, regardless of whether oxygen-containing or halide-containing hydrocarbons were injected into the ion source. Upon correct adjustment of the magnetic guide field, the current to the collector C will amount to 98 to 100 percent of the cathode current. Thus it is evident, that very few electrons strike the anode.
235. There is another way in which the ion source used for analytical purposes must differ from a standard ion source, namely, the temperature of the gas in the ionization chamber must be kept constant. In order to achieve this, the ionization box was milled from a piece of nichrome and was provided with small heating channels. Heating wires similar to the heating elements of indirectly heated cathodes could be placed in these channels. At one place a "Chromel-Copel" thermoelement was joined by means of Cu-Ag eutectic solder mixture and titanium hydride. It was insulated by a porcelain pearl.
236. This arrangement insured a good thermal contact, and at the same time a good electrical insulation was obtained between the ionization box, and the thermoelement. The leadin of thermoelements was made with molybdenum-fused wire. The ends were connected with each other so as to be good thermal conductors and electrical insulators, both within and outside the vacuum.

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237. The difference between the thermal voltage as compared to a fixed voltage, was transformed into an alternating current and was amplified and then used for the control of the heating current. The appropriate circuit diagram is given in Figure 34 [see page 106]. In order to keep the absorption of the electrode surfaces as small as possible, all parts were polished to a high mirror finish and then were gold plated.
238. Only the electron-current control mechanism of this ion source was tested by source, and the separation effect that might possibly be produced by the magnetic guide field was investigated. A brief account of the results of this control test has been given above. During tests with a mixture of He, Ne, and A, no separation effect could be found; the accuracy was within approximately 0.5 percent.
239. Prior to the commencement of the tests with hydrocarbons, which were delayed because no pure mixtures were placed at disposal, and they consequently had first to be procured in Moscow, the order suddenly came to crate the ion source and the two control units. They were then sent through the First Section (Secret Section) of Agudzeri to an unidentified installation. 25X1

#### Ion Source with Hot Anode

240. The development using a hot anode as an ion source for uranium ions was begun in order to make possible the measurement of  $U_3O_8$  and other nonvolatile uranium mixtures without prior chemical treatment, that is, by changing the mixture to  $UF_6$  or  $UF_4$ . The Soviets evidently feared the chemical treatment phase as a source of contamination, and they frequently gave the assignment of making measurements without chemical treatment of this sample. 25X1
- Any random pure uranium mixtures should be measurable in a mass spectrometer without prior conversion into  $UF_6$  or other easily volatile mixtures. Later, however, it was discovered that the Soviets also wanted mixtures included with other compounds. These mixtures might, under certain circumstances contain only one percent uranium. 25X1
- the solution to this problem was possible only in the rarest of cases and thus did not even consider it. 25X1
241. A strip of tantalum 1.2 mm wide, 15 mm long, and 0.025 mm thick served as the hot anode. In the middle of the tantalum strip a groove 10 mm long, 0.5 mm deep, and 0.8 mm wide was stamped. This groove was filled with wolframite powder with a grain size of approximately 1.2 micron diameter. The wolframite powder, in turn, was suspended in alcohol. The groove was filled to the edges. The strip was then mounted and gradually heated and degassed in a vacuum up to a temperature of 2,300° C. In the course of this heating, the majority of the impurities was evaporated. The procedure was stopped when a vacuum of approximately  $10^{-6}$  mm Hg was

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7.5 mA • 10

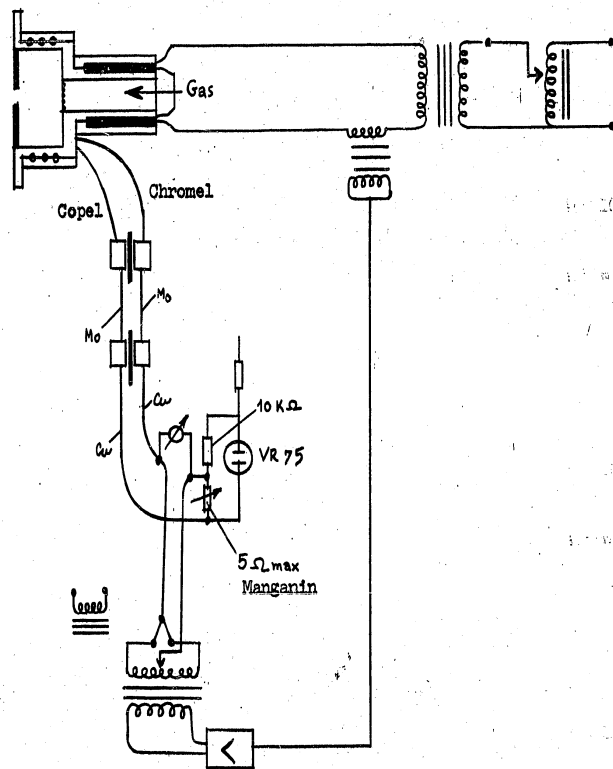


Figure 34; Arrangement to Obtain Constant temperature in Ionization Chambers

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obtained. At this point, the ion emission had become very small and consisted only of  $\text{Na}^+$  and  $\text{K}^+$  ions. These, too, could be removed by heating for about 20 to 30 hours at  $2,000^\circ\text{C}$ . Every now and then, emissions of  $\text{W}^+$  and  $\text{WO}^+$  were also observed, but evidently only when, in addition to the W-powder, oxygen-containing compounds such as  $\text{Al}_2\text{O}_3$ ,  $\text{SiO}_2$ , or  $\text{U}_3\text{O}_8$  were also contained in the anode. These observations were not part of the research program, and the problem was not examined in greater detail in Agudzeri.

242. To produce uranium ions, the sintered and baked W-powder was soaked in a small quantity (approximately 0.1 mg) of soluble U-compound and then dried in air. If necessary, it was also decomposed in oxide and finally degassed in a vacuum. The observed ions were  $\text{UO}_2^+$ ,  $\text{UO}^+$ , and  $\text{U}^+$ , and the relative intensity was dependent on the temperature. At low temperatures, only  $\text{UO}_2^+$  ions occurred, and only at higher temperatures did the  $\text{UO}^+$  ions make their appearance, as did the  $\text{U}^+$  ions. During this process, the  $\text{UO}_2^+$  ions became gradually less abundant, while the  $\text{U}^+$  emission increased. Towards the end, the  $\text{UO}^+$  emission, too, disappeared completely, leaving only  $\text{U}^+$  ions.

243. This phenomenon was more closely investigated in connection with the  $\text{O}_2$  gas generation. 25X1  
 this work was primarily done by his Soviet assistant Ketovana Grigoryevna Ordzhonikidze.  
 an intensity distribution of the type depicted in Figure 35 [see page 108] was obtained in these experiments.

244. To heat the ion source, an alternating current of 1.2 to 1.5 v and currents up to 20 A were commonly used. The voltage drop along the anode was consequently only of the order of magnitude of  $\pm 0.7$  v, and thus did not reduce the resolving power of the instrument. In experiments in which the relationship of  $^{235}\text{U}$  to  $^{238}\text{U}$  was to be measured with this anode, the alternating-current filament (AC heating) was not sufficiently constant. It was for this reason that a storage battery was used, which was charged during the experiments by means of a rectifier with  $\text{U}^+$  approximately the same current as the heating current. This led to the production of very constant ion currents of  $\text{UO}_2^+$ , except for the diminution dependent on time and resulting from the exhaustion of the anode. For that reason, an attempt was made to discover whether the evaporation of  $\text{UO}_2$  from the glow anode was ideal, that is, whether the separation effect of the magnitude  $\sqrt{\frac{M_1}{M_2}}$  was obtained or not. A very pure  $\text{UF}_6$ ,  $\frac{^{238}\text{U}}{^{235}\text{U}} =$

188.4, was measured and converted to  $\text{U}_3\text{O}_8$ . This  $\text{U}_3\text{O}_8$  was kept red-hot for one week in an electric oven and in an air current temperature of  $800^\circ$  to  $1,000^\circ\text{C}$ , in order to obtain the oxygen isotope concentration of air. At this high temperature, it may be expected that there will be no differences in the isotopic concentration between the solid and [Text continues on page 108]

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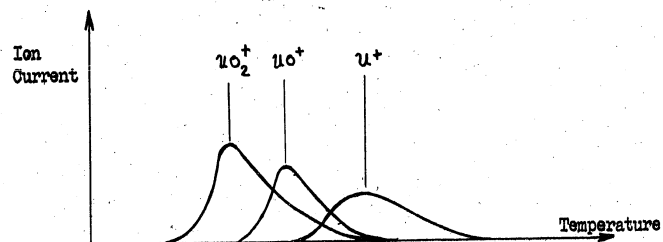
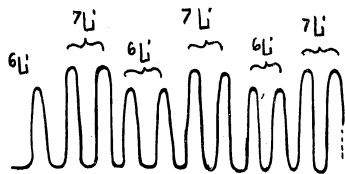
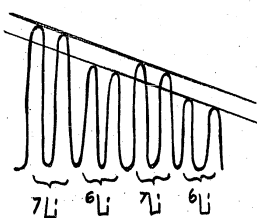


Figure 35; Ion Current as Function of Temperature



(a) Ion currents with rapidly changing intensity



(b) Ion currents with slowly changing intensity

Figure 36; Sample Speed-up Recordings

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the gaseous stage. In an  $UO_2^+$  ion, the intensity of the lines  $^{235}U\ 16_0\ 16_0^+$  and  $^{238}U\ 16_0\ 18_0^+$  were then compared for the mass numbers 267 and 272. If the uranium has the frequency ratio  $138.4 \pm 0.3$  and oxygen  $0.00204 \pm 0.000003$ , then the expected result will be  $\frac{^{238}U\ 16_0\ 18_0}{^{235}U\ 16_0\ 16_0} = 0.567 \pm 0.002$  if

no separation has occurred. In the event of an ideal separation, a reading of  $0.567 \pm 0.002 = 0.561 \pm 0.002$  should be obtained.

$$\sqrt{\frac{272}{267}}$$

245. The actual results which were obtained at the anode, together with a large quantity of uranium oxide, were around  $0.564 \pm 0.002$ ; that is, they were approximately halfway between the above values. It is, therefore, possible to assume that a separation takes place; but the separation is not ideal, probably because of the insufficient supply of material from below the surface of the anode, when the surface has become depleted of light molecules. This effect appears to be real enough, although its magnitude is close to the limit of the measuring accuracy.
246. In making further experiments, the emission from lithium ions from a W-powder anode was examined. This gave rise to interesting observations. The recording method used was as follows. Conventionally and necessarily, the peaks are recorded very slowly, so that a sufficient measuring accuracy is obtained and, above all, so as to obtain a flat cap for the peaks. If this, however, is applied to lithium, then too much time will elapse between the recording of  $^6Li^+$  and  $^7Li^+$  and much recording paper will be wasted. For this reason, a device was constructed which would regulate the magnetic current in such a manner that the two peaks for  $^6Li^+$  and  $^7Li^+$  could be recorded within a short time and the empty interval between would be jumped over. Then the changes in the magnetic current would be reversed, and  $^7Li^+$  followed by  $^6Li^+$  would be recorded. When registering the  $^7Li^+$  currents, the sensitivity of the registration device was at the same time made smaller by a factor of exactly 10. A Speedomax recorder served as the registration device. This was carefully adjusted and fed by a constant-voltage transformer, and had an accuracy of 0.1 percent in a range from 0.5 to 0.9 of full deflection. Thus the ion currents of an ion source, which under certain circumstances had a life span of several days, could be recorded continuously with a minimum of time spent on a single measurement. An example is given in Figure 36 (a) [see page 108]. Even for ion currents with slowly changing intensity, it was possible to show the relationship of the currents at any given moment. Figure 36 (b) is a recording of such a case [see page 108].

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247. Since it was thus possible to obtain for the entire life span of an anode measuring values at regular time intervals, it was also possible to determine the natural isotopic relationship in the following way:

$$\alpha_{Li} = \frac{\int_0^T i_7 dt}{\int_0^T i_6 dt} = \frac{\sum_{t=0}^{t=T} i_7(t)}{\sum_{t=0}^{t=T} i_6(t)}$$

(T = Anode's Lifetime)

The value for the abundance ratio  $\alpha_{Li}$ , which is thus determined, is  $12.49 \pm 0.02$ ; and it is independent of the quantity of Li (anywhere between  $10^{-10}$  to  $10^{-4}$  g) that has been deposited on the anode, regardless of the compound in which the lithium is applied (LiF, LiCl, LiBr, LiI, LiOH, LiNO<sub>3</sub>, Li<sub>2</sub>SO<sub>4</sub>, Li<sub>2</sub>CO<sub>3</sub>) and irrespective of the current strength at which the anode is kept as a result of the temperature ( $10^{-8}$  to  $10^{-12}$  A). The acceleration voltage was also varied between 500 and 2,500 v without showing any influence whatever.

248. This differs very much from the time variation for the individual values of  $\alpha$ . Here, too, no influence had been noticed because of the current strength, acceleration voltage, or the type of mixtures. The applied quantity, on the other hand, exhibited a noticeable effect. In Figure 37 [see page 111] the values of  $\alpha$  are shown as a function of time for four different quantities of Li ( $10^{-10}$  g to  $10^{-4}$  g) in an anode with 30 mg W-powder. The anode was degassed at a low temperature, so that a few seconds after the emission temperature had been obtained it was already possible to make measurements. The ion currents were kept relatively constant through a slow and step-by-step increase in the temperature, which would insure optimum measuring accuracy for the recording device. The initial value for  $\alpha$ , extrapolated to obtain the value corresponding to  $T = 0$ , was  $11.43 \pm 0.02$ ; thus an obvious separation had occurred. This was evidenced by the more rapid evaporation of the lighter isotope. The separation factor

$$\sigma = \frac{12.49 \pm 0.02}{11.43 \pm 0.02} = 1.093 \pm 0.003 \text{ was considerably larger than}$$

$$\sqrt{\frac{m_7}{m_6}} = 1.0800 \text{ (using mass values of Li, given by Lauritsen, and others).}$$

[Text continues on page 112]

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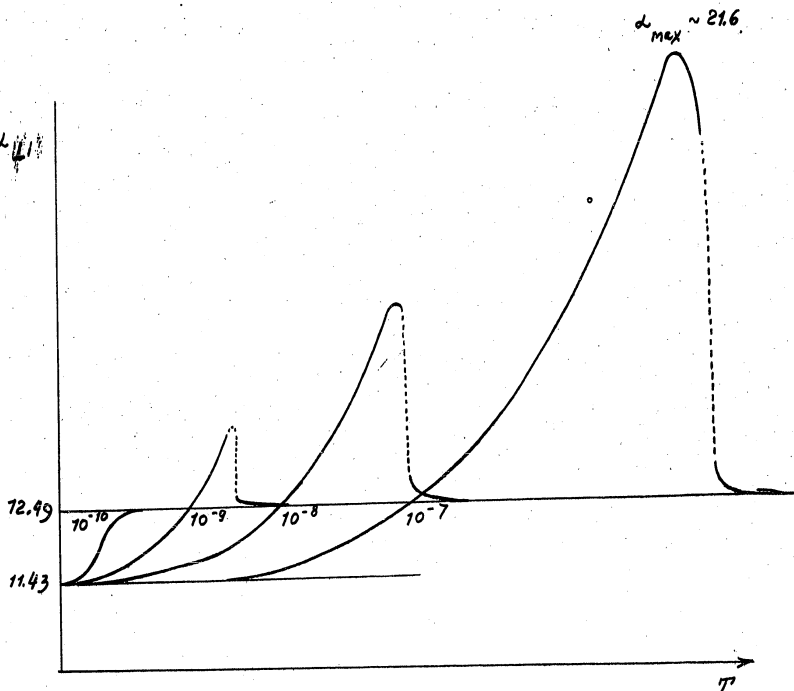


Figure 37; Isotope Ratio as a Function of Time.

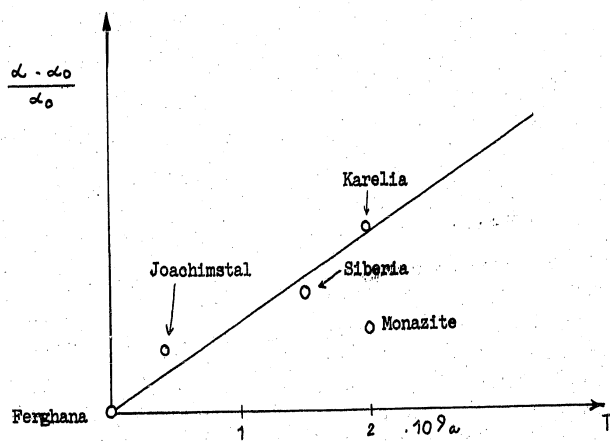
(for Lithium quantities from  $10^{-7}$  to  $10^{-10}$  gram)

Figure 38 Age Lithium Isotope Ratio Relationship for Uranium-Rich Minerals

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249. This difference can only be the result of different vapor pressures of the lithium isotopes.

$$\sigma = \frac{p_6}{p_7} \cdot \sqrt{\frac{n_7}{n_6}}$$

Upon introducing the above values, the value 1.012 is obtained for  $\frac{p_6}{p_7}$ ,

that is, the vapor pressure of  $^6\text{Li}$  is, at the initial emission temperature of  $\sim 800^\circ\text{C}$ , approximately 1.2 percent greater than that of  $^7\text{Li}$ . The result is rather surprising, for a quanta-mechanical estimation of the pressure differences, although the spin influence is neglected, yields values that are roughly 100 times smaller [for  $\frac{p_6}{p_7} - 1$ ]. The initial

value for  $\alpha$  is, depending upon the applied quantity of  $\text{Li}$ , constant for a shorter or longer time at  $k = 11.43$ ; but soon the  $\text{Li}$  remaining becomes depleted of  $^6\text{Li}$  in the anode, and the  $\alpha$  values begin to grow. The law which governs this is almost exactly the Reileigh law for ideal distillation. The correlation will be best if one assumes a separation factor which is dependent on temperature, as is the case in the  $10^{-7}\text{ g}$

$\text{Li}$  curve. The initial value for  $\sigma$  is  $\sigma_0 = \frac{p_6}{p_7} \cdot \sqrt{\frac{n_7}{n_6}}$ , and the final value is  $\sigma_2 = \sqrt{\frac{n_7}{n_6}}$ .

250. A rigorous testing of the law  $\sigma = f(T)$  is, however, not possible, since the evaporated quantities of  $\text{Li}$  cannot be determined accurately enough as a function of time because of the finite degree of ionization. The maximum  $\alpha$  that has been obtained stands in obvious relation to the quantity of  $\text{Li}$  used, and will be obtained at an emission temperature of  $1,500^\circ$  to  $1,600^\circ\text{C}$  independently of the quantity of  $\text{Li}$ . If one calculates the remnants of  $\text{Li}$  in the anode at which the ion currents become so small that a measurement of the isotope ratio is no longer possible, then for these very small amounts there will be obtained values between  $10^{-11}$  and  $10^{-12}\text{ g}$  independent of the deposited quantities of  $\text{Li}$ . This calculation is performed with simplified assumptions, using the degree of ionization and the rate of evaporation obtained when  $\alpha$  is at a maximum. Upon achieving the maximum, the  $\alpha$  values drop off very quickly, but are not accurate enough to permit measurement from which to construct a curve. This results primarily from pulses of ions which are emitted but are not reproduced by the recording device. In the interval between  $1,600^\circ$  and  $1,700^\circ\text{C}$ , no  $\text{Li}$  ions were found; but surprisingly a fairly constant emission of  $\text{Li}$  ions sets in once more at temperatures in excess of  $1,800^\circ\text{C}$ . The  $\alpha$  value that was then obtained amounted to  $12.49 \pm 0.02$ , which is

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exactly equal to that of the natural value of  $\alpha$ . The duration of the second emission process was, when the applied quantity of Li exceeded  $10^{-10}$  g, proportional to the quantity of W-powder in the anode. It is, therefore, permissible to assume that during the degassing of the anode at low temperatures ( $\sim 700^\circ \text{C}$ ) a W-Li alloy is formed (containing approximately  $10^{-4}$  percent Li), which will disintegrate only at high temperatures of approximately  $1,800^\circ \text{C}$ , and will in the process release Li of normal isotopic composition. This Li will not reside in the anode at this high temperature, but instead will ionize and evaporate as the alloy decomposes. It can, therefore, not be exchanged and, consequently, must have the natural isotope composition.

251. The objection that the temperature of the surrounding electrodes is high enough, because of the high temperature of the anode, to permit the Li vapor of normal isotope composition to be ionized at the anode has been negated as a result of the following experiment. An anode which had been heated in the first process up to  $1,700^\circ \text{C}$ , and which had been fully exhausted, was selected and built into a new ion source which as yet had never been in contact with lithium. Again, the same phenomena was found in the second process at emission temperatures of over  $1,800^\circ \text{C}$ . Finally, natural isotopic composition was used in the externally formed anode of different but known isotopic composition and the expected  $\alpha$  values were again obtained.
252. This yields a simple and precise method for the determination of the lithium composition of very small quantities of lithium. With this simple method the isotopic contents of lithium in various minerals was measured, and the following results were obtained:

a. Typical Li-Minerals

Bone charcoal from the Caucasus  
 Lepidolite from the Kazakhskaya SSR  
 Amblygonite from the Erzgebirge  
 Zimwaldite from the Pyrenees  
Result:  $\alpha = 12.49 \pm 0.02$

b. Lithium Impoverished Minerals

Colorless, red, brown, black, tourmaline from the Urals, Caucasus, and Erzgebirge.  
 Muscovite from Ceylon, Madagascar, the Caucasus, and Canada  
 Feldspar, phlogopite, angite  
Result:  $\alpha = 12.48 \pm 0.03$

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c. Lithium in Mineral Sources of the Caucasus

Borzhomi [N 41-55, E 43-25]

Yesentuki (No. 4 and No. 20) [N 44-15, E 42-45]

Saume [not located]

Avaddiara (10<sup>0</sup>) [not located]Zugdidi (86<sup>0</sup>C) [N 42-25, E 41-55]Result:  $\infty = 12.49 \pm 0.02$ d. Lithium in Very Small Concentrations

Miocene lime from the Sukhumi area

Pyrite lumps

Lead glaze (?)

Psilomelane (Chiatura [N 42-15, E 43-15])

Boron minerals in which the boron isotopic composition varied very strongly.

Boracite )

Colemanite ) From the "Tinder Lake" in Kazakhskaya SSR

Pondermite )

Result:  $\infty = 12.48 \pm 0.04$ 

253. The samples were always taken from inside a larger piece of mineral by means of hard-chromed steel tools, and were applied to the anode without any preliminary chemical processing. Consequently, no contamination from laboratory equipment was possible even for the most lithium-im-poverished minerals. It was in most cases out of the question that the lithium was already dissolved, for example, in the adhesive mountain moisture.
254. The result was a complete constancy of  $\infty$  which was contrary to the variations found by Thode and his colleagues in the next higher element, boron. In the process, it was also possible to confirm Thode's findings at least in terms of order of magnitude, although it was not possible to apply as accurate a method of measurement to the boron as had been used for lithium.
255. Since the experiments showed that there really existed no mineral in which lithium was not demonstratively present, an attempt was made to measure the  $\infty$  values for Li in old uranium and thorium. The few available minerals showed that even here it was always possible to identify lithium, and that there existed a correlation between the isotopic-abundance ratio and the age of the minerals:

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<u>Mineral</u>	<u>Age</u>	<u>%Li</u>	<u><math>\alpha</math>Li</u>
Pitchblende, Joachimstal	$2.3 \cdot 10^8$	$\sim 10^{-4}$	12.93
Uranite, Siberia	$1.7 \cdot 10^9$	$\sim 10^{-4}$	13.3
Uranite, Karelia	$1.99 \cdot 10^9$	$\sim 10^{-5}$	13.6
Tjujammuit (sic), Ferghana	$\sim 10^7$	$(\sim 10^{-2}?)$	$12.50 \pm 0.02$
Monazite, Karelia	$2 \cdot 10^9$	?	13.1
Sand from Turkestan 0.1 % U	?	.	$12.49 \pm 0.02$

256. The Li contents were only estimated from the duration of the emission and from the model tests, and it is for that reason that nothing more precise is known about the relationship of age and changes in the isotopic relationships. In minerals rich in uranium, [redacted] a 25X1 simple relationship such as that depicted in Figure 38 [see page 111] existed between the isotope ratio and the age of the mineral.

257. It is quite possible that in this way a very simple and empirical method can be derived for the determination of the age of all uranium and thorium minerals, for they must contain uranium and lithium concentrations. [redacted] three meteorites (chondrite) 25X1 had just been submitted to the institute, as well as a few moldavites. The results, however, are not known [redacted]

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#### AUTOMATIC GAS ANALYZER

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259.

in December 1949, the official order or confirmation for this assignment (it was called an analyzing apparatus in Agudzeri) was given by Gen. Zverev. Zverev emphasized at this point that the analyzer project would have a priority immediately below that of the construction of mass spectrometer No. 5 and mass spectrometer No. 6 in the laboratory in Agudzeri.

260. It was clear from the start that to dispense with cooling agents was possible only if oil diffusion pumps were used. It was, however, also clear that in the absence of cooling water serious difficulties would be encountered as result of the extreme summer temperatures, if cooling devices were to be eliminated. With a Freon cooling apparatus, however, it would be possible to work with mercury diffusion pumps. It was for this reason that two variants of the gas analyzers were built, based on the following principles:

a. First Gas Analyzer:

1. Oil diffusion pumps.
2. Analyzer and ion source to be heated to approximately  $200^{\circ}\text{C}$  in order to reduce gas absorption by the walls and condensation of the oil vapor.
3. A retarding potential placed on collector so that the strayed ions, which have suffered energy losses, will not be included in the measurement.
4. Ion source with relatively high gas pressure in the ionization chamber, so that the influence of the decomposition products of the pump's oil will be reduced.
5. Constant magnetic field; varied acceleration voltage.
6. Electrostatic focusing of the electron beam within the ion source, so as to prevent the occurrence of any separation effect.

b. Second Gas Analyzer:

1. Mercury diffusion pumps with a cooling trap at  $-60^{\circ}\text{C}$ .
2. Analyzer heated to approximately  $+200^{\circ}\text{C}$  in order to prevent any gas absorption by the walls.
3. Normal mass spectrometer system with a normal ion source and electrostatic focusing of the electron beam.
4.  $\text{Hg}^{+}$  and  $\text{Hg}^{++}$  ions will not interfere as the instruments are to be constructed only for masses between 12 and 60.

261. Experiments with the oil diffusion pumps showed that it was possible to obtain continuous pressures from  $(1.5 \pm 2) \cdot 10^{-7}$  mm Hg with Soviet pump oil "S", if special measures were taken. The main thing in this connection is that the oil "S" supplied be subjected to a high-vacuum

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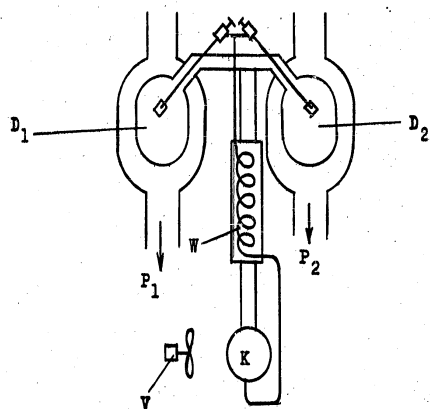
distillation in the following manner: the first 20 percent which comes through is discarded, and the main fraction from 20 percent to 70 percent is used as pumping oil. The remainder, which evidently contained a substance which was not highly volatile but easily decomposed, yielding  $\text{CO}_2$ ,  $\text{H}_2\text{O}$  and  $\text{C}_2\text{H}_4$ , was also discarded. The smallest available oil diffusion pumps (Type V M F 5 of the Distillation Products Co. (US) ) were used. The arrangement used is sketched in Figure 39 [see page 118]. The two pumps ( $P_1$ ) and ( $P_2$ ) which evacuate the ion source and the analyzer chamber were operated at 15 percent below normal capacity. The pump  $P_3$  served as a booster, and was heated at five percent above the heating rated by the factory.  $P_4$  was a "Hypervac" backing pump.

262. In the operation with HF and  $\text{HF}_2$ , another absorption vessel filled with soda lime was switched in between the pumps  $P_3$  and  $P_4$  for the purpose of absorbing the acid vapors. The chamber for the ion source and the analyzer was heated to  $+200^\circ\text{C}$ . The pumps  $P_1$  to  $P_3$  were cooled with water of about  $15^\circ$  to  $17^\circ\text{C}$ . In this way it is possible at the beginning to obtain within the hot analyzer chamber a gas pressure of  $(1.5 \pm 2) \cdot 10^{-7}$  mm Hg, and in a continuous operation and without changing the pump oil it is possible even after four to six weeks to obtain pressures of  $(3 \pm 4) \cdot 10^{-7}$  mm Hg. The measuring instrument was an ionization manometer which recorded pressures in atmospheres. For obvious reasons, this instrument was very sensitive to air penetration.
263. The other pump system was provided with two home-made mercury diffusion pumps  $P_1$  and  $P_2$ , somewhat like the Leybold Model "G".  $P_3$  was not necessary. Between the spectrometer tube and the pumps, two cooling traps were refrigerated with a system operating with Freon at  $-60^\circ\text{C}$ . A sketch of this arrangement is given in Figure 40 [see page 118].
264. The Freon compressor was removed from a ZIS household refrigerator and provided with stronger air cooling so that continuous operation was insured. The pressure measurements within the analyzer tube was somewhat difficult because of the relatively high mercury pressure. Source recalled that pressures of approximately  $6 \times 10^{-7}$  mm of mercury were obtained in Agudzeri. The interference levels of  $\text{H}_2\text{O}^+$  and  $\text{CO}_2^+$  ions and of many hydrocarbon lines were from 25 to 100 times lower than those obtained when operating with oil diffusion pumps. Both pump systems, when continuously operated for weeks at a time, showed themselves to be quite reliable, even though the Freon compressor was somewhat overloaded. It would, therefore, be necessary to design an adequate Freon compressor if the apparatus were to be industrially produced.
265. Even though the first pumping system seemed to be less suitable than the second for mass spectrometric tasks as described above, source nevertheless decided in favor of the oil diffusion pumps for the first
- [Text continues on page 119]

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K Reciprocating compressor  
W Cooling coil  
D<sub>1</sub> D<sub>2</sub> Adjustable jets  
V Fan for cooling the compressor

Figure 40; Arrangement OF Pumps Used In Second Gas Analyzer

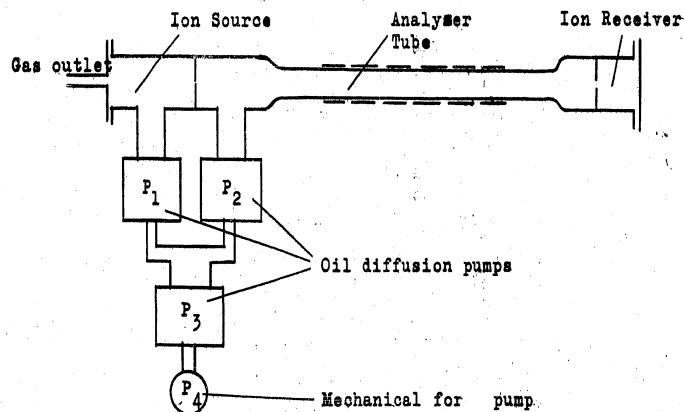


Figure 39; Arrangement Of Pumps In First Automatic Gas Analyzer

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analyzer which he built. The principal reason for this choice was the suspected unreliability of the Freon compressor and the unavailability of other small refrigeration systems. As result of this choice, the mass spectrometer for the gas analyzer was tailored on an inferior pump system, with the aim of determining its limitations. In case the system failed, [redacted] the original requirements set by Zverev and Kikoin.

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266. Since a measuring accuracy of a few percent was adequate for the analyzer's tasks, it was possible to experiment with a relatively insensitive electrometer system with high resistors of  $10^{12} \Omega$ , for example, and to raise the gas pressure in the ion source accordingly, so that the background lines would not appear in the spectrum.
267. This method was pursued in Agudzeri. [redacted] an analyzer with an inside radius 100 mm and a deflection angle of  $\varphi = 90^\circ$ . In order to make use of the largest possible divergence angle of the ion source, an oblique entry of the ion beams into the magnetic field was selected. At  $\varphi = 90$ , there will be:  $\varepsilon' = \varepsilon'' = 26^\circ$ . A permanent-magnet cast piece taken from the helium leak detector was utilized for the analyzer field. Figure 41 [see page 120] is a sketch of the magnet used.
268. Because of the small distance of the end surfaces from the magnetic center, it was necessary to determine the slope of the end surfaces experimentally. The stray field at the end surfaces was measured and the slope and the distance of the graphically determined, effective polar ends were ascertained. At first these end-surfaces were made at  $\varepsilon = 20^\circ$ , and it was determined that the effective polar ends had a slope of only  $16^\circ$ . Then step by step the angle  $\varepsilon$  was gradually increased until the slope of the effective polar end was  $26^\circ$ . [redacted] but is not absolutely certain, that for the  $26^\circ$  it was necessary to select  $\varepsilon' = \varepsilon'' = 31^\circ$ , and that the effective polar end had a distance of  $\sqrt{12}$  mm from the geometric polar end. The relationships were relatively unfavorable because of the nearness of the polar center, but should have been sufficient for such a simple mass spectrometer. As the resolving power was as high as 70 to 80 when slits of 0.5 mm were used, no further tests were made to determine the efficiency of the focusing system.
269. The ion source used with this analyzer was of the Nier type, that is, an ion source with electrostatic focusing of the electron beam. The injection of  $UF_6$  into the ion source will considerably reduce its life span. For this reason, it is best first to remove the  $UF_6$  by permitting it to react with Hg vapor. At the same time, the free fluorine that might be present in the gaseous mixture will be removed. The reaction vessel that was used for this purpose is depicted in Figure 42 [see page 121].
- [Text continues on page 122]

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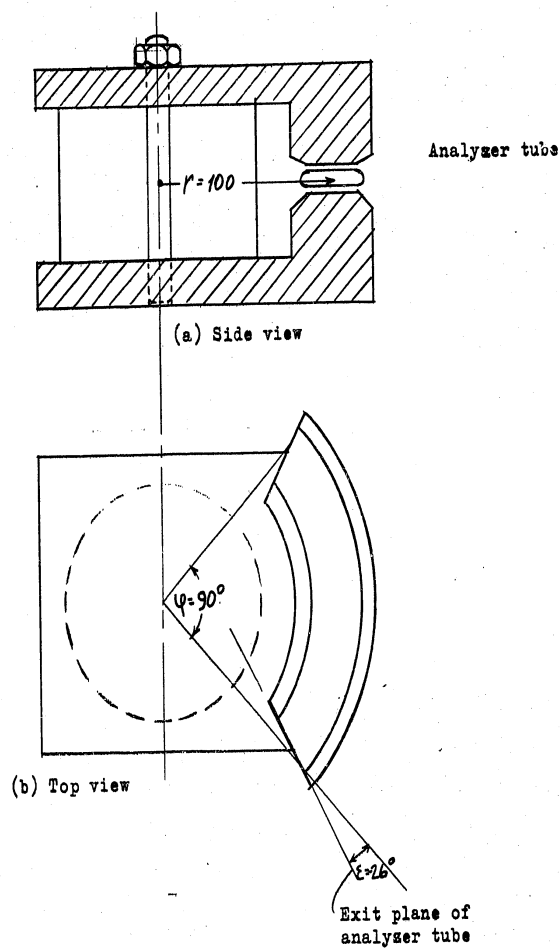


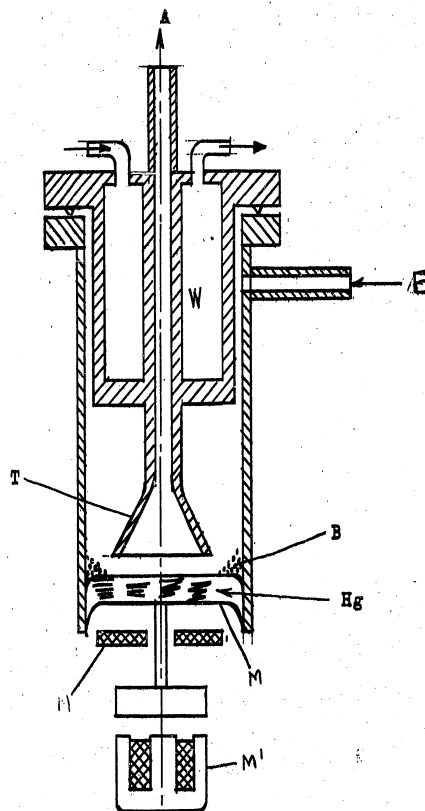
Figure 41; Magnet Used For Gas Analyzer

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[See paragraph 291 for description of operation]

Figure 52; Gas Purifier Used With Gas Analyser

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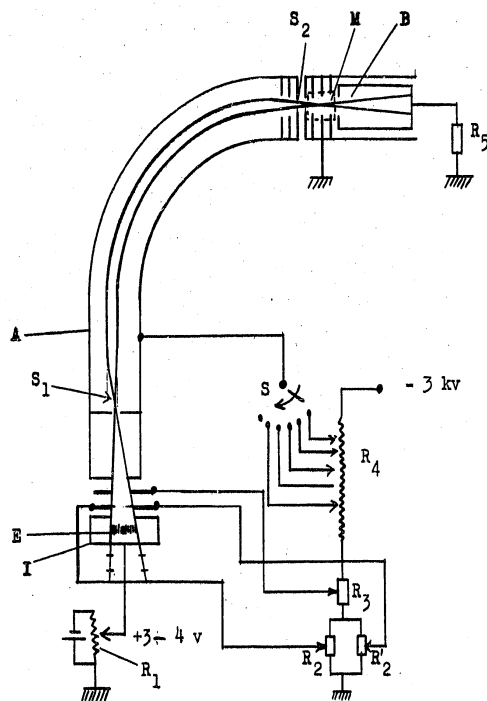
270. The collectors for the ions were maintained at a retarding potential. Thus, only those ions could be measured which had lost no more than 2eV energy. This was necessary, as a higher gas pressure was used in this ion source, in order to have the lines that are to be measured sufficiently high over the background lines of the hydrocarbons. The basic principle is illustrated in Figure 43 [see page 123].
271. The anode of the ion source I containing the electron beam E was grounded by way of the potential divider  $R_1$ . The voltage across  $R_1$  was adjusted in such a manner that the ion currents in the collector B amounted to approximately 80 percent of the maximum currents. This was found to be the case at a voltage between three and four volts.
272. Because of the effect of the acceleration field in the anode, the ions will then have an energy of approximately 2eV in the collector B. With the aid of the potentiometers  $R_2$  and  $R'_1$ , the ion beam will be directed into the slit  $S_1$ , and the maximum current strength will be adjusted by means of  $R_2$ . The different masses will then pass through the analyzer tube A and pass through the slit  $S_2$  by the application of different acceleration voltages by way of the potential divider  $R_4$  and the rotation of the switch S. The collector B will be grounded by way of the high resistances  $R_3$ . By means of an automatic compensation device, care is taken that the collector potential will always be independent of the current and will be at zero. Consequently, the same energy will be available in the rear of slit  $S_2$  no matter what kind of ions and currents are used. As the retarding field behind the slit  $S_2$  has the characteristic of withdrawing secondary electrons from the analyzer chamber and also from the aperture walls and permitting these to reach the collector, the following was done to reduce the effect of this retarding field: In front of and behind the slit  $S_2$ , an aperture system was provided. This reduced the number of secondary electrons considerably. Furthermore, a weak magnetic field (M) produced by four magnetized apertures was mounted parallel to the slit  $S_2$  which deflected the secondary electrons released by the apertures. As a result, no secondary electrons were any longer noticed in the collector.
273. All apertures, as well as the slit  $S_2$ , were coated with carbon black. The collector B, which was designed as a Faraday cage, was approximately eight cm in depth, and not even the magnetic field M could cause the escape of secondary electrons from the collector. Consequently only pure ion currents were measured. This collector system was found to be extremely reliable, and it was still possible to measure at the mass 67-68 ( $BF_3^+$ ) the adjacent lines  $SCF_2^+ M = 66$  with an intensity of only  $10^{-3}$ .
274. A Brown recorder designed for use with thermal elements served as an indicator-register. It was remodeled for application with the analyzer. The unit had 12 channels, of which eight were used for
- [Text continues on page 124]

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- A Analyser tube
- B Ion receiver
- E Electron Beam
- I Angle of ion source
- S<sub>1</sub> Exit slit of ion source
- S<sub>2</sub> Entrance slit of ion receiver
- M Auxiliary magnetic field at collectors
- R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub>, R<sub>5</sub>, Resistors
- S Switch (multipole type)

Figure 43; Schematic Circuit Diagram Of Ion Source Supply For Gas Analyzer

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the recording of eight different masses. One channel served for the recording of the zero point, and another channel for the automatic constancy regulation of the zero level. The two remaining channels were used to register the gas pressure in front of the inlet valve or the gas consumption. Both were measured with a Pyran gauge. Twenty seconds were required for the recording of one channel; consequently the entire cycle could be swept through in four minutes.

275. The measurement of the ion currents was performed with a simple vacuum-tube electrometer containing a high resistor of approximately  $4 \times 10^9$  ohms. As it is very important for the correct functioning of the collector system that the potential of the collector be as nearly equal to zero as possible, a compensation switch was selected which would supply the grid of the electrometer tube exactly the same negative bias as the positive voltage drop produced in the high resistor by the ion currents. The basic circuitry is depicted in Figure 44 [see page 125].
276. The voltage drop produced by the ion current  $i$  in the high resistor  $R_1$  brings about a disequilibrium in the bridge existing between the resistors  $R_2$ ,  $R_3$ , and  $R_4$  and the internal resistance of the electrometer tube  $E$ , and thus the inverted converter amplifier of the Brown recorder receives an input signal. The motor  $M$  shifts the slip-wire potentiometer  $P$  and produces a negative grid bias for the electrometer tube, which is equal to the voltage drop across  $R_1$ . Thus, the bridge again returns to equilibrium. The condenser  $C$  and the transformer  $T$  serve as the "elastic" feedback for damping the control oscillations. In every twelfth registration channel, the magnetic clutch  $M'$  was operated. The latter grounds the grid of the electrometer tube by means of the switch  $S$  and, upon the appearance of a disequilibrium in the bridge, adjusts the resistor  $R_3$  until an equilibrium has again been obtained. As a result, the electrometer could be operated for weeks within the required accuracy range, that is, it was admirably suitable as an automatic mass spectrometer. Difficulties were presented only by the aftereffects within the high-ohm resistor and the thermal voltages at the switch  $S$ . Only one single after-effect-free high resistor was [redacted] in Agudzeri. The resistors which were manufactured in NII-160 all showed more or less strong aftereffects. The voltage drop at the slip wire  $D$  of the potentiometer  $P$  was made asymmetrical by means of the parallel switching of the three resistors  $R_5$ ,  $R_6$ , and  $R_7$ . Consequently the following readings were obtained at the respective points when grounded:

- a. -0.01 v
- b. 0 v
- c. 0.1 v
- d. 1 v
- e. 10 v

[Text continues on page 126]

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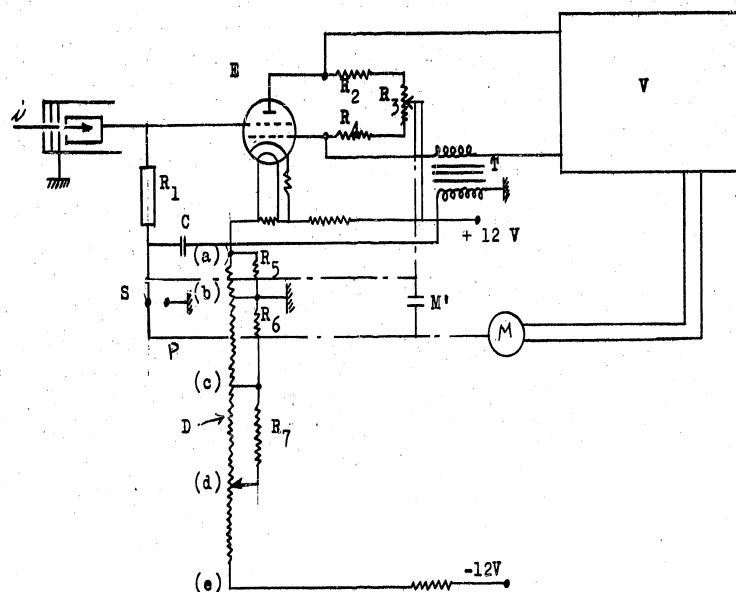
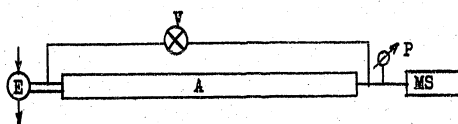
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Figure 44; Schematic Diagram of Ion Current Measuring Instrument



A Cascade  
E End volume  
V Valve  
P Pressure Gauge  
MS Gas Analyzer

Figure 45; Schematic Diagram Of Cascade Instrumentation

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It was for this reason that, for the first ten-cm deflection, 0.1 v was shown on the registration card; for the next nine cm, 0.1 v to 1 v; and for the last nine cm, from 1.0 to 10 v. It was, therefore, possible to provide on the registration card three decimal powers of the intensity scale at an approximately constant relative reading accuracy for all three decades. In so doing, a logarithmic scale was imitated, but a linear interpolation for the individual decades was assured. In such a scale, a zero-point oscillation of approximately one mm corresponds to approximately one mV. An ion current corresponding to 10 mV at the high resistance  $R_1$  could be determined with an accuracy of approximately 10 percent, while ion currents of approximately 10 v at the high resistor could be determined with an accuracy of approximately two percent.

277. For the purpose of scanning the entire spectrum, it was possible to substitute for the switch S a potentiometer which was controlled by a paper drive (Papierantrieb); and the pressure mechanism was controlled by means of a pen (stylus). It was then possible to record the spectrum from mass 10 to 60 in a period of six minutes. This process, too, could be repeated as many times as desired. Furthermore, it was possible to adjust one mass on this machine and to study its intensity curve in respect to time.
278. In addition to the ion sources described earlier in this report, only the high-voltage power supply for 5,000 v and 24 v, 150 mA supply were required to feed the electrometer tube. Both units were electronically regulated in the standard fashion and offered no unusual aspects. The heating of the pumps  $P_1$ ,  $P_2$ , and  $P_3$ , as well as the heating of the analyzer tube and the gas-inlet system, were taken from a constant-voltage transformer. This constituted the weak link of the entire system, since the line frequency was not sufficiently constant, and the constant-voltage transformer translated the frequency oscillations into voltage oscillations. Consequently, the sensitivity of the unit was not sufficiently constant in those periods in which the line frequency varied.
279. The examination of the remainder of the spectrum was performed at first without a gas-inlet system and without baking-out. The  $H_2O^+$  line at mass 18 was very strong initially but decreased gradually, whereas the hydrocarbon lines gained in intensity slowly. After twenty-four hours the  $H_2O^+$  line still possessed an intensity of around three volts at approximately  $4 \times 10^9$  L, and the most abundant hydrocarbons of the  $C_2$  and  $C_3$  group had intensities of approximately 0.5 to 1.0 v. Heating to 100° C immediately resulted in raising the  $H_2O$  line above 10 v, whereas the carbon-hydrate rose briefly to a few volts and after a few hours dropped again to 0.05 to 0.1 v. Six hours were required for the  $H_2O^+$  line to fall again to one volt. Upon raising the temperature of the system still higher, to approximately 200° C, the intensity of the  $H_2O$  line rose

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again by a few volts and then dropped quickly to approximately 0.3 v, whereupon it remained constant. The hydrocarbons dropped to 0.01 v and below after a very brief rise. New lines appeared in the form of  $\text{CO}^+$  and  $\text{CO}_2^+$ ; these were evidently decomposed products from the hydro-carbonates and from the copper parts of the analyzer. The intensities were quite considerable and diminished only gradually. For this reason, the entire analyzer, with voltages switched off, was heated for several hours at temperatures around  $500^\circ\text{C}$  and then permitted to cool approximately  $200^\circ\text{C}$ . The main lines that were then obtained were  $\text{H}_2\text{O}^+$  and  $\text{CO}^+$  of approximately 0.1 v intensity, while all other lines had intensities below 10 mV. That the line which was dealt with at a mass of  $M = 28$  was actually  $\text{CO}^+$ , and not  $\text{N}_2^+$  coming from air that had, penetrated, was proven by the absence of  $\text{O}_2^+ = 32$ , the intensity of which lay below the demonstrable limit  $\sim 1$  mV. Even the soaking of the vacuum parts with pure  $\text{O}_2$  did not change anything in the intensity of  $M = 28$ . From this, it could be inferred that these remnant intensities of  $\text{H}_2\text{O}^+$  and  $\text{CO}^+$  did not stem from pumping oil, but rather were still slowly liberated from parts of the ion source, which became heated by the radiation and the conduction of the cathode. It was impossible to determine in Agudzeri whether this was caused by metal or ceramic particles. The remnant-intensities obviously limited the measuring accuracy of small  $\text{H}_2\text{O}$  and  $\text{N}_2$  additives (admixture), but the error was smaller than the absorption and exchange effects. In order to test whether, as a result of reactions within the ion source, interferences are brought about, the following procedure was applied in Agudzeri:

280. The test gas-agent used was the purest  $\text{O}_2$ , which could be introduced into the ion source through an electrically-heated, tiny silver tube. This was generated from the purest  $\text{KMnO}_4$ , which was heated in a vacuum; and the  $\text{CO}_2$  and  $\text{H}_2\text{O}$  admixtures possibly present were removed by freezing them out in liquid air. The density of the silver tube was tested by filling the gas-inlet system with neon. This guaranteed that the oxygen was very pure. Nevertheless, there were noticed in addition to  $\text{O}_2^+$  and  $\text{O}^+$  an intensification of the  $\text{H}_2\text{O}^+$ ,  $\text{CO}^+$ ,  $\text{C}_2\text{O}^+$ , and  $\text{CO}_2^+$  lines upon the admission of  $\text{O}_2$ . At approximately 10 v oxygen intensity, there occurred a rise in the intensity of the  $\text{H}_2\text{O}^+$  line from approximately 0.1 v to 0.3 v; the  $\text{CO}^+$  rose from 0.05 v to 0.4 v, and the lines  $40 = \text{C}_2\text{O}$  and  $44 = \text{CO}_2$ , which had earlier not been noticed, now recorded intensities of approximately 0.08 v. The intensities of the  $\text{H}_2\text{O}^+$  and  $\text{CO}^+$  lines were proportional to the  $\text{O}_2$  pressure; for the other two lines, it is probable that an additional quadratic component applies. This effect, too, limits the measuring accuracy of the analyzer when used in connection with gas mixtures containing strong oxygen components.

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281. Next the effect on the analyzer produced by pure, water-depleted  $\text{H}_2\text{F}_2$  was tested. If the purest  $\text{H}_2\text{F}_2$  entered the new apparatus, then first, everything would react on hydroxides or hydrocarbons that were located along the walls. This was true even if the apparatus had first been carefully baked-out. Fluorides would then form along the walls, which would later passivate the apparatus and would also, to a very high degree, absorb water and other mixtures containing OH-groups. After the walls had fully reacted, the  $\text{HF}^+$  ion would become easily measurable, and its intensity would be proportional to the pressure of HF in the supply chamber. The pressure was low and the temperature was high enough so that all  $\text{H}_2\text{F}_2$  molecules would have been disintegrated. After the passivation with HF had been completed, the reactions of  $\text{O}_2$  with impurities of the walls would be much smaller than they had been earlier, and HF that had been absorbed along the walls would be released by the  $\text{O}_2$ . This was true, although it took several hours after the valve had been closed before the  $\text{HF}^+$  line would drop by one percent of its initial intensity. If, on the other hand, a mixture of  $\text{H}_2\text{O}-\text{N}_2$  was permitted to enter, then the  $\text{N}_2$  partial pressure would be correctly reproduced, whereas the  $\text{H}_2\text{O}$  would be insufficiently reproduced. Instead, for every missing  $\text{H}_2\text{O}$  molecule approximately 1.3 HF molecule would be developed. It took quite a while before a stationary condition was achieved and  $\text{H}_2\text{O}$  was reproduced which corresponded to the partial pressure.

282. Absorbed  $\text{H}_2\text{O}$ , HF, as well as absorbed  $\text{CH}_3\text{OH}$  and  $\text{CH}_2\text{OH}$ , could be removed only very slowly by means of evacuation, even if this evacuation was performed at temperatures up to  $200^\circ\text{C}$ . It could be done faster with a flushing method in which the absorbed molecules were flushed away by the excess of the molecules that were to be measured next. This, however, was also time consuming, with the result that the analysis of gas mixtures containing  $\text{H}_2\text{O}$  and HF was very difficult. It was possible to establish the composition with an accuracy of  $\pm 10$  percent when the analyzer had for some time been recording constant partial pressures. Upon changes of the analyzer's registration for the  $\text{H}_2\text{O}^+$  ion and for the  $\text{HF}^+$  ion, it was, if changes were in the same direction, frequently not possible to say whether it was the partial pressure of  $\text{H}_2\text{O}$  or that of HF, or both, which had changed. In that case, errors were made that were often 100 percent. It was clear, therefore, that for  $\text{H}_2\text{O}$  and HF the gas analyzer was anything but an ideal measuring instrument; yet at the same time it was still better than continual, momentary recordings and registering methods.

283. Judging from the many test analyses, it was possible to obtain a measuring accuracy of from two to three percent for the elements and compounds:  $\text{O}_2$ ,  $\text{N}_2$ ,  $\text{CO}$ ,  $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{Ne}$ ,  $\text{Ar}$ , etc., if the concentration was no smaller than five percent. At a later stage, the gas analyzer was used to test the enrichments obtained in the counter-current cascade, especially when the problem dealt with studying the relationship of more than two components. A schematic diagram of the test arrangement is given in Figure 10 [see page 125].

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284. Let A be a cascade; at the light end there is located a final volume E, through which atmospheric air that has been purified of water vapor and carbon dioxide is sucked in such quantity that the concentration of the particles passing through the cascade remains practically unchanged. At the heavy end of the cascade, the gas-analyzer mass spectrometer and the pressure registration instrument P are connected. The gas consumption of the analyzer is so very small that the cascade operates practically without extraction. The cascade is shorted by a conductor which, at the time  $t = 0$ , will be interrupted by the valve V, so that the separation process may begin. A graphic depiction of the concentration of  $N_2O_2$  and A in respect to time is shown in Figure 46 [see page 130]. For purposes of checking, the total pressure was calculated from the measured partial pressures and was then compared with the measured total pressure.
285. Curves were obtained of the type shown in Figure 46 [see page 130] and they showed a measuring accuracy of approximately  $\pm 3$  percent. After the stationary condition had set in, gas was continuously extracted from the heavy end of the cascade and the concentration was measured.
286. The curves given in Figure 47 [see page 130] were exactly inversely swept through. The third attempt to measure the distribution along the cascade in a stationary condition was not made because of the multiplicity of connections that would have been required. It was suspected that such an experiment would have yielded similar sets of curves.
287. If  $H_2O$  and  $CO_2$  were not removed from the air, there was obtained a five-component mixture, for which the family of curves is shown in Figure 48 [see page 131]. Because of the small quantities of  $CO_2$ , it was not possible to obtain a stationary condition for  $CO_2$ . For this reason there occurred the strange phenomenon that at small extractions the concentration of the final product yielded was higher than it was without extraction.
288. During the operation of a cascade with borontrifluoride, experiments were made to measure the boron isotope enrichment and the generation of HF caused by the corrosion from  $H_2O$  remnants or hydrocarbons. The analyzer was connected to the light end of the cascade, while a 30-liter vessel of  $BF_3$  was connected to the heavy end. The gas could thus circulate first through the vessel. The depletion of  $^{10}BF_3$  was then measured with the large mass spectrometer, after the stationary condition had been obtained. The enrichment of  $^{10}B$  at the light end of the cascade was measured with the analyzer. The results of this test are depicted in Figures 49 and 50 [see page 132].
- [Text continues on page 133].

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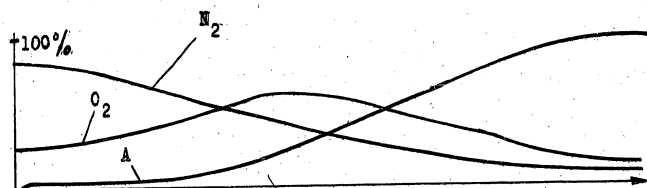
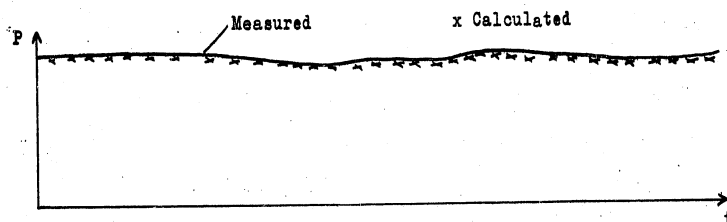


Figure 46; Variation in Concentration of Constituents at the heavy end of a Cascade.



—— Measured with manometer  
 x x x Sum of partial pressures as measured  
 with gas analyser

Figure 47; Total Pressure Of Gas At Heavy End Of Cascade

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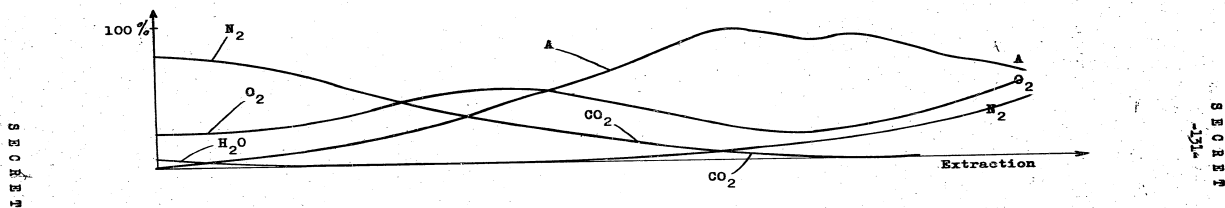


Figure 48; Variation Of Concentration Of A 5-Component Mixture In Heavy End Of Cascade Measured With Gas Analyser

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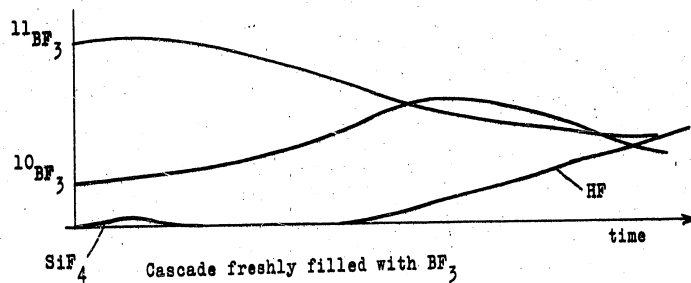


Figure 49; Analysis Of Components Of Light End Of A Cascade For Separation Of Boron Isotopes

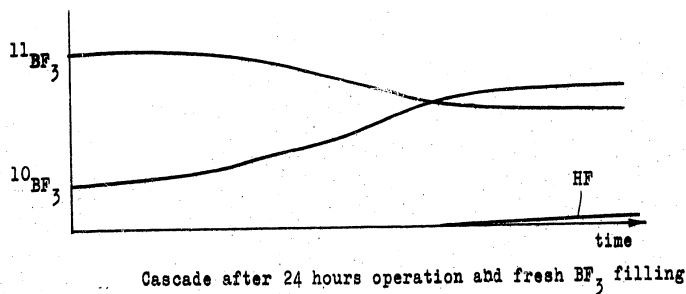


Figure 50; Analysis of Components of Light End Of A Cascade For Separation of Boron Isotopes.

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289. The interpretation of these results is somewhat difficult for the countercurrent cascade, but it does explain why in earlier tests there had frequently occurred a diminution of the enrichment and yield as time passed. Too little attention was given to the corrosion and the generation of gasses within the cascade. This, of course, was a direct result of the speed that was required in order to keep step with the Plan.
290. If the total pressure was calculated from the measured partial pressures of  $^{10}\text{F}_2$ ,  $^{11}\text{F}_2$ , and HF, then there would not be obtained as pretty a correlation as in the case of the argon-air separation. Source was unable to remember any details, except that the pressure registered by the gas analyzer was too low. Given more time and more care, it would probably have been possible to analyze more accurately gases containing fluorines but from which all the free  $\text{H}_2\text{O}$  had been removed. The cascade was [redacted] 25X1 for only a very short time. [See Figure 42, page 121].
291. The gaseous mixture was permitted to enter the vessel at E and then streamed downward along the outside walls and counter to the mercury surface Hg. A membrane M which was given oscillations of approximately 0.1 mm amplitude by means of the magnet M', would continuously jar the mercury, so that its surface was continuously renewed. The  $\text{UF}_4$  and  $\text{HgF}_2$  which condensed along the surface would become continually divided by these oscillations and thus would gradually be pushed to the edges where it would slowly accumulate at point B. As a result, the mercury would always remain free of surface layers and could thus evaporate normally. By means of the heating element H, the mercury was raised to a temperature of approximately  $50^\circ$  to  $60^\circ$  C. The gases that did not react with the Hg departed by way of the funnel T to the exit A. The head of the vessel in which the reaction took place was cooled with water; this prevented excessive amounts of Hg from entering the gas analyzer. With this apparatus, it was possible to liberate such large quantities of  $\text{UF}_6$  from a gas stream of one cm<sup>3</sup> NDT/hour of 50 percent  $\text{UF}_6$  and 50 percent A, that less than  $10^{-5}$   $\text{UF}_6$  was permitted to pass. The apparatus with its large surfaces had, however, the disadvantage of increasing the adjustment time required for the HF recording and, furthermore, it had a strong tendency to absorb water. A measurement of the  $\text{H}_2\text{O}$  partial pressure was hardly possible with such large surfaces and water cooling. On the other hand, this was hardly necessary when working with gaseous mixtures containing  $\text{UF}_6$ , as the  $\text{UF}_6$  immediately reacted with  $\text{H}_2\text{O}$  and thus removed all the  $\text{H}_2\text{O}$ . No experiments were made with a  $\text{UF}_6$  cascade, since all the cascades were continuously required for other purposes.

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292. It had been planned to heat the fluorocarbon mixtures, which had been used in the Hertz' countercurrent pumps, together with UF<sub>6</sub> in a special vessel and to study the formation of HF and CF<sub>4</sub> as a function of time. The experiments were started and HF and CF<sub>4</sub> were actually determined. Unfortunately, however, the experiments had to be discontinued, as the machine had to be demonstrated at this point to a Soviet commission. The experiments were not resumed at a later time.

SOVIET PERSONALITIES

25X1

293. The following is a list of Soviet personalities below the ministerial level

25X1

Abramovich (fnu)

In charge of the dismantlement of the Siemens Research Department in Berlin during 1945.

Alekseyev (fnu)

In 1953, he headed the mass-spectrometric laboratory in the Academy of Sciences Laboratory for Vacuum Problems headed by Vekshinskiy (fnu). Worked on a mass spectrometer with stigmatic focusing and with ~3,000 resolving power. A number of mass spectrometers from NII-160 were available in the mass-spectrometer laboratory. Representatives from Alekseyev repeatedly visited Agudzeri

25X1

Alikhanov\* [possibly Abram Isaakovich]

Physicist. Professor, Dr., member of the Academy of Sciences. Was chief of an institute engaged in atomic research, probably dealing with reactor problems. Between 1946 and 1950, he visited Agudzeri and Sinop repeatedly. His specific interest, if any, could not be determined, because he inspected virtually every scientific section in the institutes. Gave lectures at both institutes, dealing with cosmic-ray radiation; some of these lectures were published. Was considered a most able scientist but with a tendency towards irresponsibility and rashness in judgement. Has been awarded three or four Stalin Prizes. A very pleasant individual. Spoke English.

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Artsimovich\* (fnu)

Physicist. Professor, Dr., member of the Academy of Sciences. Headed an institute of the Academy of Sciences in Moscow in which the problem of electromagnetic isotope separation was studied. At meetings of the Scientific-Technical Council [redacted] Artsimovich exhibited great interest in mass-spectrometer problems. Visited Agudzeri repeatedly between 1945 and 1955.

25X1

Blokhintsev\* [Dmitriy Ivanovich]

Physicist. Professor, Dr. In 1946, was a Referent in the Ninth Directorate. During this period he visited Agudzeri very often and showed interest in the mass-spectrometer development and in isotope separation. During 1948, he was appointed head of the Obninskoye nuclear research installation. During April-May 1955, Blokhintsev demonstrated the Soviet atomic power plant to the visiting German purchasing commission [redacted]

25X1

[redacted] Blokhintsev had just been released from prison in 1946, in order to accept the post in the Ninth Directorate.

25X1

Bonch-Bruyevich\* (fnu)

Played a major role in outlining the initial requirements for [redacted] mass spectrometer development work in the USSR.

25X1

Chevchenko (fnu)

Professor, Dr., member of the Academy of Sciences. Headed Laboratory 9 in Moscow, at which the Max Vollmer group and the Robert Doepel group worked.

Demirkhanov,\* Rach Aramovich

Dipl. Physicist assigned to Sinop. For a long time he was the assistant and deputy to Manfred von Ardenne until he received his own group, which worked on problems similar to those of von Ardenne. From 1945 to 1948, Demirkhanov worked on the design of a mass spectrometer; from 1948 to 1950, on the design of ion sources for electromagnetic isotope separation. Together with von Ardenne, he worked for long periods of time in an unidentified institute located in Leningrad. He later built a mass spectrograph in Sinop, which operated without (later with) double focusing and in principle was based on the Bainbridge-Jordan design. Also engaged in the development of proton sources and on the problem of generating multiple-ionized atoms. In 1953, he worked on

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his kandidat dissertation, but had not completed work at the time of the Germans' departure in March 1955. In 1955, was appointed chief of the mass-spectrometer laboratories in Agudzeri and Sinop. In 1954, was awarded the Stalin Prize, Second Class, together with the German specialists Heinz Ernst Froehlich and von Ardenne, and several unidentified Soviets. Considered to be very ambitious and capable, but also dishonest in human relations, a characteristic which has in the past caused him considerable difficulty.

25X1

Frumkin [probably Aleksandr Naumovich]

25X1

Identified [ ] as having participated in meetings of the Scientific-Technical Council [ ]

25X1

Golovin (fnu)

25X1

Physicist [ ] at the Ninth Directorate headquarters. Was interested in mass spectroscopy. [ ]

25X1

[ ] no knowledge of Golovin's role in the Soviet atomic program.

Inozemtseva\*, Irina [Aleksandrovna]

From 1946 to 1950, Referent in the Ninth Directorate responsible for chemical development tasks and especially corrosion problems. From 1952 until 1955 was assigned to Nikolaus Riehl's chemical group in Agudzeri, wherein she worked as an assistant to the German specialist Helmut Bunnon the purification and crystallization of germanium. Had an affair with the Soviet deputy technical director of Agudzeri, Kvartskhava, and in 1951 gave birth to his child.

Ioffe [possibly Abram Fedorovich]

Professor, Dr., member of the Academy of Sciences. Participated in meetings of the Scientific-Technical Council [ ] During 1948, he visited Agudzeri.

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Isayev\*, Boris Mikhaylovich

Prior to 1952, he was assigned to an institute in Sungul where he headed a laboratory engaged in dosimetry. In 1952, he was appointed deputy director of the combined installations at Agudzeri and Sinop, and in this capacity headed a group of scientific sections or departments which were collectively known as OKB. [redacted] mass-spectrometer laboratory, although located in Agudzeri, was subordinated to Isayev's OKB, whereas Isayev's office was in Sinop. In 1954, Isayev was appointed director of the combined installations in Sinop and Agudzeri, and thus was Migulin's immediate successor. Isayev's specialty was in the field of radiation-measuring methods. He was awarded at unspecified dates the Stalin Prize Second Class and the Stalin Prize Third Class. [redacted] Isayev lacked a thorough, basic all-round physicist background, and his forte was technical (applied) development.

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Kirvalidze, Irakliy (pnu)

Dipl. Physicist and graduate of Tbilisi University. From the end of 1945 to 1946, assigned to the laboratory of Karlfranz Zuehlke in Agudzeri, and from 1947 to 1955 assigned to Sinop. During the last two years (1953-1955), he headed a semiconductor laboratory in Sinop.

Leontyev\* [possibly Nikolay Ivanovich]

Electrical engineer. Prior to 1950, he was assigned to an atomic research institute in Obninskoye, possibly with [Aleksandr Il'ich], Leypunskiy's section. In 1950, Leontyev was assigned as an assistant to source's mass-spectrometer laboratory in Agudzeri. Was very industrious [redacted]

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[redacted] Leontyev was preparing for make-up examination as Dipl. Physicist, and at the same time [redacted] was engaged in preparing his kandidat dissertation of which the theme was "Nuclear Absorption of Protons for Use in Measuring Magnetic Fields." This paper was published. [redacted] Leontyev was engaged in writing a paper dealing with a cyclotron for measuring atomic weights. Leontyev was a very active member of the Party.

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Lukyanov [Anatoliy Grigoryevich]

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Dr. Phil., professor, physicist. [redacted] not certain of Lukyanov's [redacted]

Lukyanov always seemed to appear when mass-spectrometric questions [redacted]

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were being elucidated. Was particularly interested in the mass spectrograph [redacted] constructed between 1953 and 1955. Equally interested in mass measurements of nuclear moments. Was a participant at the colloquia held in Sukhumi during 1952 and 1953. 25X1

Mykhnišv (fnu)

Lieutenant general of the MVD and adjutant to Beriia; charged with atomic research questions. During 1945, requisitioned the two sanatoriums in Sukhumi which became the sites of the Institute A and Institute G. Was seen [redacted] in several meetings of the Scientific-Technical Council. 25X1

Novikov\* [probably Ivan Ivanovich]

During 1947, he held the post of Referent in the Ninth Directorate under Yemelyanov. May have been responsible for the field of isotope separation. In 1950, was one of two Referenten who maintained scientific liaison between the Sukhumi installations and the supervisory agency in Moscow. From 1953 to 1954, he was on sabbatical leave, which he devoted to compiling a reference book of tables on thermal problems. In 1952, was awarded Stalin Prize, Second Class. Novikov [redacted] was a specialist in thermal engineering and heat-transfer problems. It is very probable, [redacted] that Novikov held a chair at a Moscow institute, and thus held the academic degree of doctor and possibly professor. 25X1

Popov\* [possibly Aleksandr Aleksandrovich]

Physicist assigned to Agudzeri installation until 1952. Was assigned to Hertz's section working on countercurrent-diffusion, and later (1952) to the small "supersecret" Hertz section that probably worked on tritium (see EG-1685). Accompanied Hertz to an unidentified installation in Moscow towards the end of 1952.

Rik [G.R.]

Dr. Phil., physicist. Assigned to the Radium Institute (RIAN) of the Academy of Sciences located in Leningrad. Was engaged in problem dealing with age determination of uranium minerals and also with lead-isotope analysis. [redacted] Rik was writing a book on mass spectroscopy. 25X1

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Semënov\* (fnu)

Physicist, kandidat, docent at a Moscow institute in which he heads a laboratory for high-frequency measuring engineering. From 1949 to 1954, he was also one of two Referenten (Novikov was the other) who maintained technical-scientific liaison between the two Sukhumi installations and the supervisory agency (First Chief Directorate and later the Ministry of Medium Machine Building) in Moscow.

Seymovskiy (fnu)

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Director of NII-628 in Moscow which was an institute devoted to the metallurgy of magnetic alloys. No further details

Shoherbin (fnu)

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Smorodinskiy\* [probably Ya. A.]

Dr. Phil., professor and possibly a corresponding member of the Academy of Sciences. Held chair possibly in theoretical physics at Moscow University. His position in the Soviet atomic research program was not known. In 1953, he participated in mass-spectrometer colloquium in Agudzeri. He was a recipient of a Stalin Prize First Class.

Talroze (fnu)

Physico-chemist assigned to an unidentified institute of the Academy of Sciences located in Moscow. Used a mass spectrometer supplied by NII-160 in Fryazino for experiments in hydrocarbon analysis. He has worked on the formation of  $CH_5^+$  and  $OH_3^+$ . He participated in mass-spectrometer colloquium held in Agudzeri during 1953.

Veksler\* [Vladimir Iosifovich]

Assigned to unidentified installation. Participated in mass-spectrometric colloquium held in Agudzeri during 1953.

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Vinogradov\* [Aleksandr Petrovich]

Participated in meetings of the Scientific-Technical Council [redacted] 25X1  
[redacted] Headed the Geo-Chemical Institute of the Academy of  
Sciences in Moscow. This institute was believed [redacted] to be 25X1  
connected with the uranium-prospecting program in the USSR. 25X1

Yermina [Natalya Nikolayevna]

Chemist who worked with her husband [Vladimir Nikodimovich] Yerminev on tubular barriers after the death of Reichmann in Agudzeri. Accompanied her husband to Elektrostal in 1950/1951.

Zadorozhniy\*

Physicist and possibly Dr. Phil. Worked in Vinogradov's Geo-Chemical Institute wherein he headed the mass spectrometric laboratory. Between 1938 and 1948, constructed a Bainbridge-Jordan mass spectrograph which, however, never became fully operative. Received from Agudzeri one of source's mass spectrometers, with which he performed lead analysis, the results of this were published in open Soviet scientific journals. Had planned to organize a large mass-spectrometric laboratory at the new site of the Vinogradov institute.

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